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INDUSTRIAL WASTE TREATMENT STUDIES. MC CLELLAN AIR FORCE BASE, SACRAMENTO, CALIFORNIA

Herbert R. Pahren, et al

Sanitary Engineering Center
Cincinnati, Ohio

1957

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INDUSTRIAL WASTE TREATMENT STUDIES

McCLELLAN AIR FORCE BASE
Sacramento, California

April 24 to June 28, 1957

By

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U. S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service
Sanitary Engineering Center
Cincinnati, Ohio

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TABLE OF CONTENTS

	Page
SUMMARY	v
GENERAL INFORMATION	1
1. Authority	1
2. Objectives	1
3. Dates	1
4. Personnel	1
5. Laboratory Facilities	2
6. Laboratory Determinations	2
7. State Requirements	2
8. Production Levels	3
INDUSTRIAL PLANT 1	4
1. Description of Plant	4
2. Source and Description of Wastes	6
3. Samples and Preservation	7
4. Presentation of Data and Discussion	7
INDUSTRIAL PLANT 2	22
1. Description of Plant	22
2. Source and Description of Wastes	24
3. Samples and Preservation	24
4. Presentation of Data and Discussion	24
INDUSTRIAL PLANT 3	42
1. Description of Plant	42
2. Source and Description of Wastes	45
3. Samples and Preservation	47
4. Presentation of Data and Discussion	47
SEWAGE TREATMENT PLANT	56
1. Description of Plant	56
2. Source of Wastes	59
3. Samples and Preservation	59
4. Presentation of Data and Discussion	59

TABLE OF CONTENTS (Cont'd)

	Page
PHENOLIC TRACING STUDIES	68
1. Introduction	68
2. Wastes Coming to Plant 1	68
3. Wastes Coming to Plant 2	75
MAGPIE CREEK	77
1. Introduction	77
2. Samples and Preservation	77
3. Presentation of Data and Discussion	78
RECOMMENDATIONS	86
ACKNOWLEDGEMENT	87
APPENDIX	
1. Letter of Authorization	A - 1
2. Modification of Waste Plant 3 Treatment Process	A - 2

LIST OF FIGURES

Figure 1 - Plant 1 Flow Diagram, McClellan AFB	5
Figure 2 - Plant 2 Flow Diagram, McClellan AFB	23
Figure 3 - Plant 3 Flow Diagram, McClellan AFB	43
Figure 4 - Industrial Washer - Building 75B, McClellan AFB	46
Figure 5 - Sewage Plant Flow Diagram, McClellan AFB	57

TABLE OF CONTENTS (Con't.)

Page

LIST OF TABLES

1. Gallons of Waste Flow to Plant 1 8

2. Concentration and Quantity of Phenols from Pit 40 11

3. Concentration and Quantity of Oils from Pit 40 11

4. Concentration and Quantity of Phenols from Pit 41 12

5. Concentration and Quantity of Oils from Pit 41 12

6. Plant 1 Performance Test - May 6, 1957 14

7. Plant 1 Performance Test - May 7, 1957 15

8. Plant 1 Performance Test - May 21, 1957 16

9. Plant 1 Performance Test - May 22, 1957 17

10. Summary of Plant 1 Analyses 20

11. Summary of Contaminants Removed in Plant 1 21

12. Gallons of Waste Flow to Plant 2 25

13. Plant 2 Performance Test - May 16, 1957 28

14. Plant 2 Performance Test - May 17, 1957 29

15. Plant 2 Performance Test - May 20, 1957 30

16. Plant 2 Performance Test - May 23, 1957 31

17. Plant 2 Performance Test - June 4, 1957 32

18. Plant 2 Performance Test - June 10, 1957 33

TABLE OF CONTENTS (Con't.)

Page

LIST OF TABLES (Con't.)

19. Plant 2 Performance Test - June 18, 1957 34

20. Plant 2 Performance Test - June 19, 1957 35

21. Plant 2 Performance Test - June 20, 1957 36

22. Summary of Plant 2 Analyses 37

23. Summary of Contaminants Removed in Plant 2 40

24. Flow Through Plant 3 Water Meter 48

25. Summary of Plant 3 Analyses 51

26. Removal of Oil and Solids in Plant 3 Flotator 54

27. Concentration of Chemicals Added to Plant 3 54

28. Removal of Phenolics in Podbielniak Extractor 55

29. Flow of Raw Sewage to the Sewage Plant 60

30. Summary of Sewage Plant Analyses 62

31. Per Cent Reduction of Applied Concentration in Sewage Plant at Various Stages of Plant 64

32. Constituents in Sewage Plant Effluent 67

33. Concentration and Location of Phenolic Samples in Plant 1 Sewer System 69

34. Concentration and Location of Phenolic Samples in Plant 2 Sewer System 76

35. Magpie Creek Flow - McClellan Influent 79

36. Magpie Creek Flow - McClellan Effluent 80

37. Magpie Creek Phenol Analyses 83

38. Quantity of Phenol in Magpie Creek at McClellan Effluent . 84

SUMMARY

This report is based on two months intensive study of liquid wastes produced at the McClellan Air Force Base and the operation of the four existing waste treatment plants. Highlights of this work and the findings are summarized for the convenience of the reader.

1. Performance tests run at each of the four waste treatment plants provided additional analytical results essential for maximum efficiency in operation. These tests revealed efficient operation.

2. The system of waste treatment developed by McClellan personnel at Plant 3 permitted reuse of the treated waste and virtually a closed water system in the engine cleaning department. Discharge from Plant 3 is now limited to sludge withdrawal, skimmings, and bleed-off to the sanitary sewer.

3. It was demonstrated that controlled bleed-off of cresylic acid (phenolic) wastes from Plant 3 could be satisfactorily treated at the domestic sewage treatment plant with an efficiency of 95 per cent removal of phenolics.

4. Operation data revealed that Plant 1 could satisfactorily treat all wastes received without by-passing although it was operating at 15% overload during the last two weeks of June. Any expansion plans should be consistent with future requirements.

5. Phenol sources contributing to Plant 1 were located and significant phenolic wastes were diverted to Plant 3 for treatment with similar wastes and reuse.

6. The effect of abnormalities in character of wastes on treatment

efficiency was illustrated on one occasion at Plant 2. This is significant because abnormal waste flows may damage downstream public water supplies.

7. Design of each waste treatment plant provides desirable flexibility in operation. This was particularly true of the domestic sewage treatment plant which was producing an excellent effluent.

8. Magpie Creek was sampled at the point where it entered the Base, on leaving the Base, and at points downstream to determine natural purification en route to Sacramento River. Tests during late June 1957 indicated that the Base effluent approached State regulations. Phenolics in the Base effluent were approximately 1 pound per day.

9. This work served to emphasize the need for establishing positive controls and an accurate, complete system of records for the operation of these industrial waste treatment systems. Such data are invaluable in proving satisfactory treatment and protection of the receiving stream.

10. These waste treatment plants contain some highly efficient equipment. Full utilization requires vigilant operation and competent supervision.

11. The recommendations in this report have been discussed with officials of McClellan Air Force Base.

GENERAL INFORMATION

1. Authority

The official request for the services of the U. S. Public Health Service to conduct industrial waste research at McClellan Air Force Base was made in a letter dated April 9, 1957 from Lt. Col. J. B. Marshall, Installations Engineer, to the Robert A. Taft Sanitary Engineering Center. A copy of this letter is reproduced in the Appendix.

2. Objectives

The survey had several objectives. These were as follows:

a. Obtain data on the performance of each treatment plant with the view of improving operation.

b. Ascertain the source of contamination by phenolic materials in Plants 1 and 2.

c. Obtain data on the concentration of phenolic material in Magpie Creek effluent.

d. Train a chemist in the analyses of industrial wastes.

3. Dates

The survey was conducted during the period April 24 to June 28, 1957.

4. Personnel

Persons participating in the conduct of the survey were as follows:

McCLELLAN AIR FORCE BASE
Lt. Col. J. B. Marshall, Installations Engineer
Major B. A. Snodgrass, Special Projects Officer
W. Knapton, Supt. Utilities Operations and Plant Service Branch
E. J. Johnston, Foreman of Sanitary Unit
W. F. Collins, Sanitary Engineer
W. L. Miles, Deputy Chief of Installations Division
E. L. Davis, Assistant for Operations
P. Weltch, Foreman of Sewage Plant

McCLELLAN AIR FORCE BASE (Cont'd)
G. A. Root, Chemist
H. S. Dankman, Deputy Chief, Sanitary and Industrial Hygiene Engineering Section
1st Lt. F. A. Buckridge, Chemist, Sanitary and Industrial Hygiene Engineering Section
K. R. Lind, Chief, Materials Laboratories Section

U. S. PUBLIC HEALTH SERVICE
Hayse H. Black, Industrial Wastes Consultant
Carl R. Hirth, Chemist
Herbert R. Pahren, S. A. Sanitary Engineer

4. Laboratory Facilities

The laboratory was set up by the Base personnel and the Public Health Service chemist. This laboratory is located in Building 29, the former incineration building. Most of the equipment needed for the analyses was brought by the Public Health Service. Incubator space was provided by the sewage treatment plant laboratory. The industrial hygiene engineering laboratory performed a phenol analysis on samples taken on all week days from Magpie Creek entering and leaving the Base.

6. Laboratory Determinations

All laboratory determinations were made in accordance with Standard Methods for the Examination of Water, Sewage, and Industrial Wastes, 10th Edition. The 4-aminoantipyrine method was used for phenolic materials and the ether extraction method was used for total oils.

7. State Requirements

The State requirements for maximum permissible limits for water pollutants in Magpie Creek have been established in Resolution 53-48 dated November 9, 1953 by the Central Valley Regional Water Pollution Control

Board of California. These limits are as follows:

Phenolic Compounds	0.005 ppm
Nickel	1.0 ppm
Cyanide	0.1 ppm
Chlorides	350 ppm
Copper	3.0 ppm
Lead	0.1 ppm
Zinc	15 ppm
Total Dissolved Solids	2100 ppm
Boron	2.0 ppm
Hexavalent Chromium	0.05 ppm
Per Cent Sodium	75%
$\left(\frac{Na \times 100}{Na + Ca + Mg + K}\right.$ Expressed in milliequivalents $\left.\right)$	
pH	6.5 - 8.5
Oils	20 ppm

Odor No offensive odor from Magpie Creek

No material or chemicals likely to cause taste or odors in a domestic water supply shall be discharged to Magpie Creek.

Discharge shall not contain materials in amounts toxic to human beings, animals, or fish life.

8. Production Levels

In order that present waste loads may be compared to waste loads of the future it is necessary to compare production for the respective periods. The production level and the amount of waste generated is considered proportional to the earned hours worked. Information on the present average earned hours in the various departments and the industrial waste plant which receives the waste from these departments is as follows:

	Department	Hours	Receiving Plant
46105	Disassembly and Cleaning (Aircraft)	5362	1
46205	Cleaning (Engine Branch)	6867	3
46607	Electroplating	3210	1
46613	Task Unit (Building 88)	3738	2
46504	Vehicle Section (Washrack-Bldg.655)	3737	2

The hours given are for a two week period and represent the time necessary for average persons to accomplish the work load.

INDUSTRIAL PLANT 1

1. Description of Plant

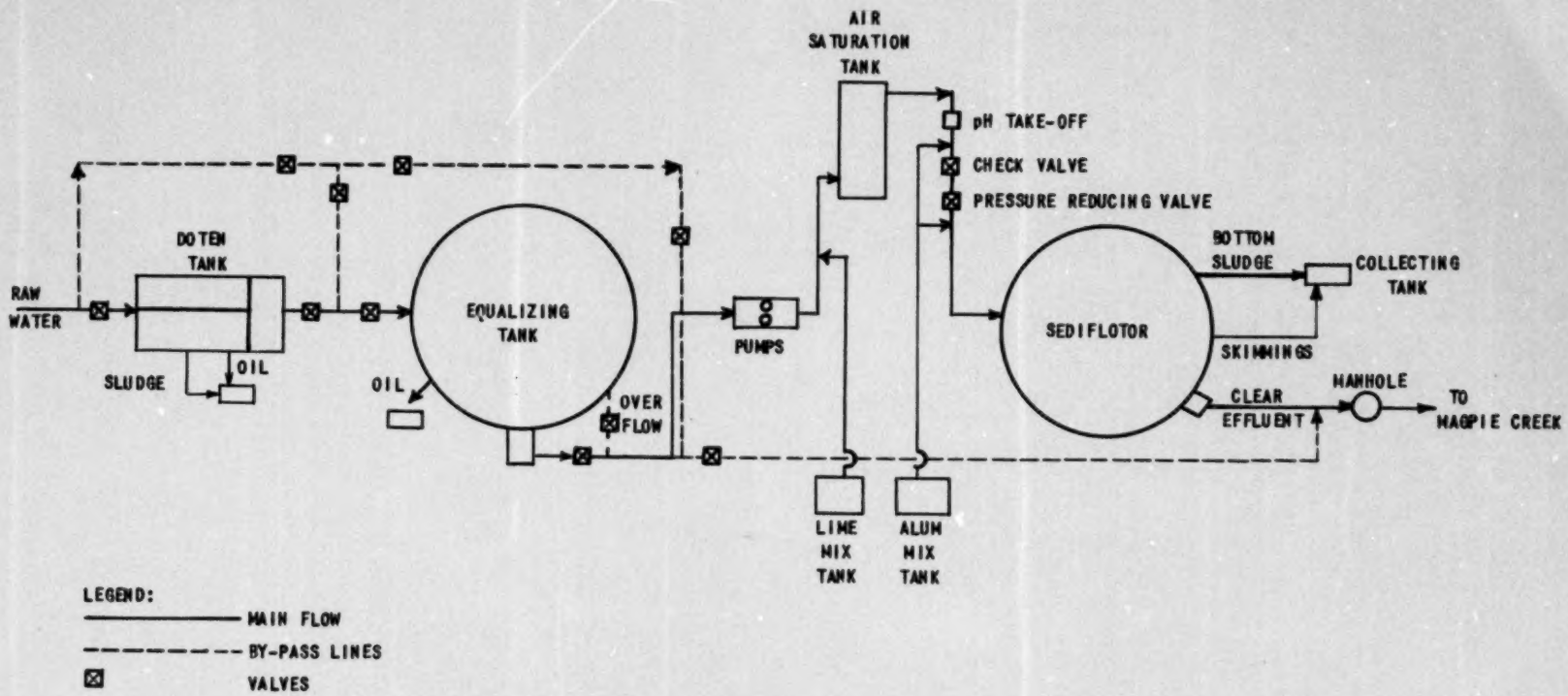
Wastes coming to Plant 1 are pumped from two pump wells, Pit 40 and Pit 41. These wastes enter the Doten tank at one end and while retained in the tank most of the free oils separate. A flow diagram of Plant 1 is shown in Figure 1.

The Doten tank consists of two basins, each 12 ft. wide, 42 ft. long and 11 ft. deep. At the downstream end of the basin, a hand operated skimming arrangement allows the top portion of the liquid to flow through a pipe and into a collecting tank. When this collecting tank is full the oil is hauled to a pit where the oil is burned.

The effluent from the Doten tank flows by gravity to a 70 ft. diameter equalizing tank. This tank is equipped for oil skimming but has no provision for bottom sludge removal.

Liquid wastes are taken from a point near the bottom of the equalizing tank and pumped through an air saturation tank to an Infilco Sediflotor. Either of two pumps can be used, each having a rated capacity of 750 gallons per minute at 90 ft. head.

Atmospheric air is introduced into the waste, by means of an injector, at the suction side of the transfer pump. This air is permitted to go into solution by holding the pressure in the system at approximately 40 p.s.i.g. A detention period of about one minute in the air saturation tank is sufficient for reasonably complete saturation at operating pressures. Excess air



PLANT I FLOW DIAGRAM, McCLELLAN AIR FORCE BASE

Figure 1

is released from the top of the tank to prevent passage of large bubbles to the Sediflotor.

From the air saturation tank, the waste passes through a pressure release valve to the bottom of the flotation unit. At the reduced pressure air is less soluble and is released from the liquid in the form of tiny bubbles. The released bubbles attach themselves to the solids, or floc, and carry the material to the surface where it is removed by a rotating skimmer. The skimmings are collected and periodically hauled away to a pit on the Base. Clarified wastes are removed through a peripheral submerged take-off and pass over a weir, through a pipe to a nearby manhole. From the manhole the wastes flow to Magpie Creek.

Chemicals are added to aid in the removal of oils and other materials in the waste. Alum is added to the waste before it enters the Sediflotor. The alum reacts with the alkalinity in the water forming aluminum hydroxide floc. The floc aids in breaking emulsions and helps to produce a clear effluent. Lime is also added, but only when the pH of the incoming water drops below 8.0.

2. Source and Description of Wastes

Wastes coming to Plant 1 from the area north of Magpie Creek flow through Pit 40. These wastes include airplane washings, weapons repair rinses, residue from metallurgical heat treatment rinses, oils, acids and paints from tank and radiator cleaning rinses, zyglo rinses, acid waters from the battery shop, paint removals and washings, plating shop rinses, floor washings, and miscellaneous residues.

Pit 41 receives the flow to Plant 1 from the area south of Magpie

Creek. These wastes include steam cleaning condensates, zyglo rinses, dry cleaning wastes, floor washings and compressor cooling water.

3. Samples and Preservation

Samples from Pits 40 and 41 were taken by means of a sampling line connected to the discharge side of one of the pumps. These samples were taken once per hour and composited over a 24 hour period. Samples for the Plant 1 performance tests were taken from the trough at the influent end of the Doten tank, a sampling cock on the pump drawing water from the equalizing tank, and at the Sediflotor effluent overflow weir. These samples were taken each half hour for an eight hour period.

Two separate samples were taken at all times. One was preserved with copper sulfate for phenol analysis and the other sample was used for the remaining determinations.

4. Presentation of Data and Discussion

During the early part of the survey, measurements were made to determine the variation of flows throughout the day and the daily quantities coming from the two pump pits. Pumping rates were calculated by timing the draw-down of water in the pit and correcting for inflow. Hourly readings were taken from a timer to determine the length of time the pump was in operation. These flow data are shown in Table 1. It can be seen that most of the flow from Pit 41 occurs during the day shift while the flow from Pit 40 is spread more evenly over the 24 hour period. The average flow for the day shift on the days measurements were taken was 291,000 gallons. This is slightly more than the Plant 1 Sediflotor will handle with only one pump operating. However, the decreased flow to Plant 1 on the swing and graveyard shifts enabled the

TABLE 1

GALLONS OF WASTE FLOW TO PLANT 1

Date 1957		Pit 40	Pit 41	Pit Totals
April 30	Mid. - 8 AM	113,000	22,000	135,000
	8 AM - 4 PM	133,000	119,000	252,000
	4 PM - Mid.	138,000	38,000	176,000
	Total	384,000	179,000	563,000
May 1	Mid. - 8 AM	134,000	13,000	147,000
	8 AM - 4 PM	183,000	128,000	311,000
	4 PM - Mid.	168,000	34,000	202,000
	Total	485,000	175,000	660,000
May 2	Mid. - 8 AM	133,000	22,000	155,000
	8 AM - 4 PM	176,000	133,000	309,000
	4 PM - Mid.	103,000	41,000	144,000
	Total	412,000	196,000	608,000
May 3	Mid. - 8 AM	129,000	38,000	167,000
	8 AM - 4 PM	188,000	99,000	287,000
	4 PM - Mid.	102,000	31,000	133,000
	Total	419,000	168,000	587,000

operators to work off the volume that built up during the day shift.

A check was made on the wastes pumped from 11:30 AM on Friday 5/3/57 to 8 AM on Monday 5/6/57. It was found that 133,000 gallons were pumped from Pit 40 and 130,000 gallons came from Pit 41. Plant 1 normally operated until 8 AM Saturday morning so there was sufficient space in the 170,000 gallon equalizing tank to hold the remaining flow on this week-end.

Measurements were also made on several days during the survey of the pumping rate of the No. 2 Sediflotor pump. The water level in the Sediflotor was first lowered and then, after starting the pump, the length of time to fill a calculated volume was measured. These results are as follows:

Date	Flow, G.P.M.
4/29/57	555
5/3/57	510
5/8/57	595
5/21/57	553

This is an average of 553 G.P.M. and is equivalent to 796,000 gallons per day. It is recognized that the pumping rate can be changed by adjusting the setting on the pressure reducing valve. However, the average flows obtained are probably typical of normal operation with one pump.

As warmer weather approached, more water had to be handled by Plant 1. This was believed due to an increased use of cooling water on the Base. Since the flow was more than the Sediflotor could handle with one pump operating, the plant personnel checked the flow rate with both pumps running simultaneously. This rate was 700 G.P.M. which

is equivalent to 1,000,000 gallons per day. During the last two weeks of June, it was necessary to use both pumps each day.

Flow over the week end also increased in June so it was necessary to operate Plant 1 on Sundays to keep the wastes from overflowing the equalizing tank and by-passing the chemical treatment. During the last week of the survey a new operator was hired and in the future Plant 1 will be operated one shift both Saturday and Sunday. This action will prevent any week end flows from by-passing the plant.

Plant 1 was designed for 600 G.P.M. flow. Thus it can be seen that the plant is at its hydraulic capacity on week days during warm weather. Operation during the week is on a three shift basis and throughput cannot be increased by adding additional shifts.

The main functions of Plant 1 are to reduce oils and suspended solids. Any reduction in phenolic materials would result only when part of these materials would be dissolved in the oil and subsequently removed.

The concentrations and quantities of phenols and oils coming to Plant 1 from Pits 40 and 41 are shown in Tables 2 through 5. These tables show the variation of wastes for the different shifts. It can be seen that most of the oil comes to Plant 1 during the day shift. Approximately equal quantities pass through Pits 40 and 41. Quantities of phenols passing through Pit 40 are relatively small and are about the same for each shift. However, the amount of phenolics passing through Pit 41 during the day and swing shifts were quite substantial. The source of these phenols was traced and the phenolic material was diverted to Plant 3. The details of this work will be presented in a

TABLE 2

CONCENTRATION AND QUANTITY OF PHENOLS FROM PIT 40

Date	12 Mid. - 8 AM Shift		8 AM - 4 PM Shift		4 PM - 12 Mid. Shift		Total
	ppb	lb.	ppb	lb.	ppb	lb.	lb.
May 1	8	0.009	14	0.013	7	0.010	0.032
May 2	85	0.094	109	0.160	112	0.096	0.350
May 3	103	0.111	25	0.039	180	0.153	0.303
Average	65	0.071	49	0.071	100	0.086	0.228

TABLE 3

CONCENTRATION AND QUANTITY OF OILS FROM PIT 40

Date	12 Mid. - 8 AM Shift		8 AM - 4 PM Shift		4 PM - 12 Mid. Shift		Total
	ppm	lb.	ppm	lb.	ppm	lb.	lb.
April 30	12	11	60	67	21	24	102
May 1	-	-	85	130	90	126	-
May 2	11	12	90	132	11	9	153
May 3	5	5	51	80	7	6	91
Average	9	9	71	102	32	41	152

TABLE 4

CONCENTRATION AND QUANTITY OF PHENOLS FROM PIT 41

Date	12 Mid. - 8 AM Shift		8 AM - 4 PM Shift		4 PM - 12 Mid. Shift		Total
	ppb	lb.	ppb	lb.	ppb	lb.	lb.
May 1	129	0.014	1260	1.35	1240	0.352	1.72
May 2	350	0.064	1040	1.15	1310	0.448	1.66
May 3	260	0.082	4830	3.99	1680	0.435	4.51
Average	245	0.053	2380	2.16	1410	0.412	2.62

TABLE 5

CONCENTRATION AND QUANTITY OF OILS FROM PIT 41

Date	12 Mid. - 8 AM Shift		8 AM - 4 PM Shift		4 PM - 12 Mid. Shift		Total
	ppm	lb.	ppm	lb.	ppm	lb.	lb.
April 30	37	7	159	158	168	53	218
May 1	35	4	87	93	10	3	100
May 2	34	6	67	74	44	15	95
May 3	29	9	72	59	54	14	82
Average	34	7	96	96	69	21	124

later section of this report.

On four different days, a performance test was made on Plant 1 to determine the efficiency of the plant and the quantity of oil and phenol discharged to Magpie Creek. The summaries of the performance tests results are presented in Tables 6 through 9.

Detention time in the Doten tank and equalizing tank allows solids to settle and free oil to separate. The three values obtained that show an oil reduction prior to the Sediflotor average 35 per cent. Most of this oil removal takes place in the Doten tank.

A small amount of oil separates in the equalizing tank but the equipment is not satisfactory to remove it. Proper oil resistant rubber blades must be installed on the skimming arms to make the oil skimmermore effective. The equalizing tank acts as a reservoir for the Sediflotor and it is not necessary to skim continuously. Periodically, when sufficient oil accumulates, the level is allowed to rise and the surface skimmed of most of the oil. If the equalizing tank is drawn down too far and part of the surface oil pumped to the Sediflotor, the oil load on the Sediflotor will be excessive.

During the tests, the quantity of coagulant was varied in order to ascertain the effect on the Plant 1 effluent. The floc helps to break any emulsions present and carries off the free oil. The dosage of alum was such as to result in a floc on the surface of the water in the Sediflotor of very thin to very thick characteristics. Although the trend showed higher effluent oil concentration when the alum dosage was lowered, there was actually little difference in the results. Even the test with a very thin floc met the Base specifications for oil content. Therefore, the data

TABLE 6

PLANT 1 PERFORMANCE TEST - MAY 6, 1957

	Oil ppm	Phenol ppb	pH	Total Alkalinity ppm
Doten in	81	407	7.0	172
Sediflotor in	137	537	7.7	144
Sediflotor out	7.4	468	6.6	69
Doten removal, %	-	-		
Sediflotor removal, %	94.6	12.9		
Flow through Sediflotor, gal/min				595
Flow, gal/min/ft^2				1.96
Alum added in Sediflotor, ppm as $Al_2(SO_4)_3$				90
Lime added in Sediflotor, ppm as $CaCO_3$				0
PPM alkalinity consumed by alum theoretically				79
PPM alkalinity consumed as found by chemical test				75

Nature of floc: Moderate

TABLE 7

PLANT 1 PERFORMANCE TEST - MAY 7, 1957

	Oil ppm	Phenol ppb	pH	Total Alkalinity ppm
Doten in	103	1067	5.8	40
Sediflotor in	55	1063	7.0	98
Sediflotor out	14	908	6.7	73
Doten removal, %	46.6	0.4		
Sediflotor removal, %	74.5	14.6		
Flow through Sediflotor, gal/min				595
Flow, gal/min/ft^2				1.96
Alum added in Sediflotor, ppm as $Al_2(SO_4)_3$				86
Lime added in Sediflotor, ppm as $CaCO_3$				59
PPM alkalinity consumed by alum theoretically				76
PPM alkalinity consumed as found by chemical test and lime consumption				84

Nature of floc: Thin

TABLE 8

PLANT 1 PERFORMANCE TEST - MAY 21, 1957

	Oil ppm	Phenol ppb	pH	Total Alkalinity ppm
Doten in	57	1354	7.6	123
Sediflotor in	40	491	7.4	126
Sediflotor out	9.3	471	6.6	60
Doten removal, %	29.8	63.7		
Sediflotor removal, %	65.0	4.1		

Flow through Sediflotor, gal/min	553
Flow, gal/min/ft^2	1.82
Alum added in Sediflotor, ppm as $Al_2(SO_4)_3$	77
Lime added in Sediflotor, ppm as $CaCO_3$	0
PPM alkalinity consumed by alum theoretically	68
PPM alkalinity consumed as found by chemical test	66

Nature of floc: Very thick

TABLE 9

PLANT 1 PERFORMANCE TEST - MAY 22, 1957

	Oil ppm	Phenol ppb	pH	Total Alkalinity ppm
Doten in	97	323	7.3	113
Sediflotor in	68	301	7.5	127
Sediflotor out	19	296	7.1	101
Doten removal, %	29.9	6.8		
Sediflotor removal, %	72.0	1.7		

Flow through Sediflotor, gal/min	553
Flow, gal/min/ft^2	1.82
Alum added in Sediflotor, ppm as $Al_2(SO_4)_3$	31
Lime added in Sediflotor, ppm as $CaCO_3$	0
PPM alkalinity consumed by alum theoretically	27
PPM alkalinity consumted as found by chemical test	26

Nature of floc: Very thin

show that in the Plant 1 Sediflotor it is necessary to build only a moderate floc to obtain a good quality effluent. Adding an excess of coagulant is a waste of chemicals.

On three of the four days on which a performance test was run, it was not necessary to add lime in order to adjust the pH. The optimum coagulation range for alum with most wastes is pH 6.0 to 8.5 and if sufficient natural alkalinity is present it is not necessary to add lime to obtain the aluminum hydroxide floc. However, if insufficient turbidity is present the floc formed may be too fine and part may carry over with the effluent. Therefore, the relatively insoluble lime, if added, could provide artificial turbidity and a more dense floc may be obtained. The use of the lime in this case would depend on the condition of the floc. A small rate of lime addition continuously may result in a heavier floc. Clay could be substituted for lime if a lower pH is desired.

Information obtained at the Base showed that Butler Hangar aircraft wash rack uses 2700 gallons of gunk per month for cleaning aircraft. This is the only wash rack now in use and all of the waste is treated at Plant 1. Compared to the total Plant 1 flow the volume of gunk is quite small and this could partially explain why Plant 1 is generally successful in obtaining a good quality effluent.

Gunk has the property of forming very stable emulsions. Once in a while, if an unusually large amount of gunk flows to Plant 1 in a short period of time, the emulsions are more difficult to break. However, this situation does not occur very often and it is not felt to be a serious problem. When recognized, this situation can usually be counteracted with a

heavier dose of chemicals.

A summary of the analyses obtained during the performance tests are presented in Table 10. The increase in oil and phenol concentrations on May 6 between the Doten tank influent and the Sediflotor influent can be explained by the deliberate time lag in commencing the sampling at the Sediflotor. The Sediflotor samples were delayed in an attempt to obtain the same waste as sampled at the Doten tank influent after allowing sufficient time for passage through the equalizing tank. Apparently the two samples were not representative of the same waste.

Table 11 summarizes the quantities of contaminants, in pounds per hour, flowing to and leaving Plant 1. It also presents the overall reduction in the plant. The oil content of the waste was reduced an average of 85.4% on the days that samples were taken. This value is probably lower than actual conditions because the amount of alum added in the Sediflotor was purposely held low during some of the tests in order to obtain a fine floc. As expected, the reduction of phenolic materials was not great.

On June 20 a composite sample was taken of the Plant 1 effluent to ascertain the reduction in the quantity of phenols being discharged. This resulted from the diversion of most of the phenolic material which formerly came to Plant 1. The 51 ppb, equivalent to 0.018 pounds per hour, represents a substantial decrease in the phenolic content of the waste.

TABLE 10

SUMMARY OF PLANT 1 ANALYSES

Date	Oil ppm	Phenol ppb	pH	Total Alkalinity ppm
Doten in				
May 6	81	407	7.0	172
May 7	103	1067	5.8	40
May 21	57	1354	7.6	123
May 22	97	323	7.3	113
Sediflotor in				
May 6	137	537	7.7	144
May 7	55	1063	7.0	98
May 21	40	491	7.4	126
May 22	68	301	7.5	127
Sediflotor out				
May 6	7.4	468	6.6	69
May 7	14	908	6.7	73
May 21	9.3	471	6.6	60
May 22	19	296	7.1	101
June 20	-	51	-	-

TABLE 11

SUMMARY OF CONTAMINANTS REMOVED IN PLANT 1

Date	Influent, lb/hr*		Effluent, lb/hr		% Removal	
	Phenol	Oil	Phenol	Oil	Phenol	Oil
May 6	0.12	24	0.14	2.2	-	90.8
May 7	0.32	31	0.27	4.2	15.6	86.4
May 21	0.37	16	0.13	2.6	64.9	83.7
May 22	0.09	27	0.08	5.2	11.1	80.7
June 20	-	-	0.02	-	-	-

*In calculations, flow into Plant 1 assumed to be same as the effluent volume.

INDUSTRIAL PLANT 2

1. Description of Plant

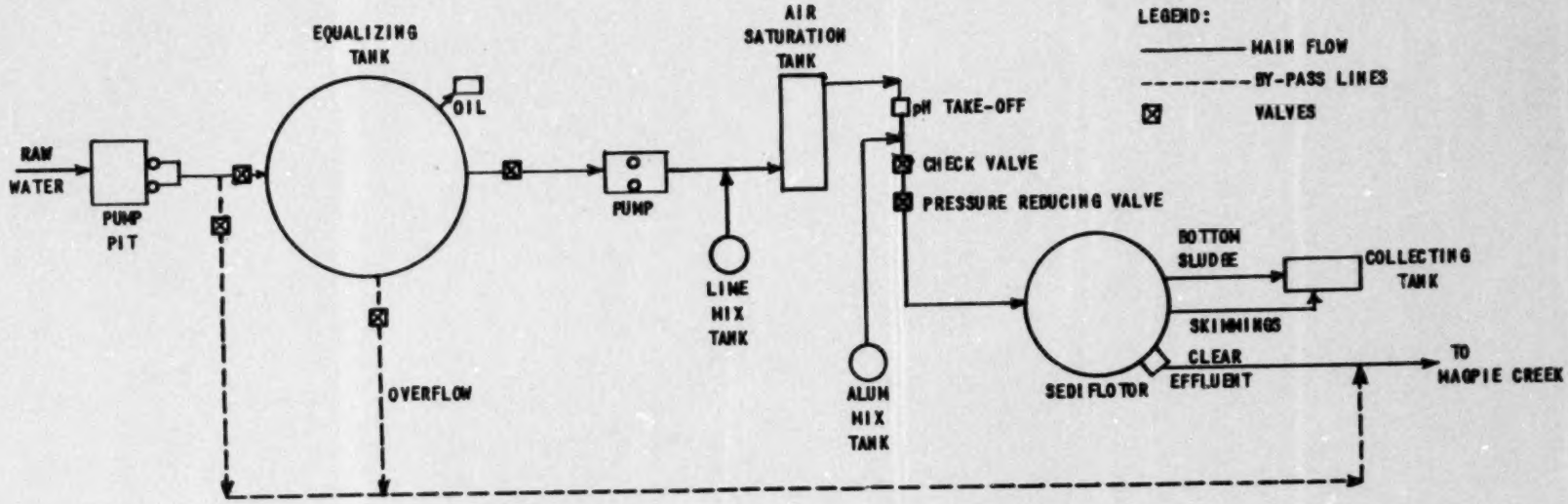
Wastes to be treated at Plant 2 are collected first in a pump well, from which they are pumped to a 22 ft. diameter, 37,700 gallon tank. This tank serves to equalize the flow, skim any free oil, and provide a reservoir of wastes for the Sediflotor. Approximately once every two weeks, the water level in the tank is allowed to reach the top so that the oil can be skimmed off. This oil is collected in a small tank and hauled to the burning pit. A flow diagram of the Plant 2 process is shown in Figure 2.

The water is removed near the bottom of the equalizing tank and pumped through an air saturation tank to the Sediflotor. Transfer is made by either of two pumps, each having a rated capacity of 94 G.P.M. at 100 ft. head.

Air is introduced into the wastes at the transfer pumps by means of an injector. After a short detention time the pressure on the system is reduced and the released air bubbles carry the oil and suspended solids to the surface of the Sediflotor.

A thin lime slurry is added to the wastes just before the air saturation tank and an alum solution is fed just after this tank. The floc formed by these chemicals aids the separation of oils and solid particles. Two mixing tanks are available for making a water solution of the dry chemicals.

Clarified wastes flow from the Sediflotor to a small ditch which, in turn, leads to Magpie Creek. The skimmed floc and any bottom sludge is collected in a small tank and periodically hauled to a pit located on the west side of the Base.



PLANT 2 FLOW DIAGRAM, McCLELLAN AIR FORCE BASE

Figure 2

2. Source and Description of Wastes

Wastes coming to Plant 2 consist of wash water from cleaning of disassembled airplane parts, paint removal solutions and rinses, vehicle and power equipment repair rinses, and floor washings.

3. Samples and Preservation

Samples for the Plant 2 performance tests were taken from a sample cock on the incoming line to the equalizing tank, a sample cock on the pump transferring wastes to the Sediflotor, and at the Sediflotor effluent overflow weir. These samples were taken every half hour for an eight hour period and composited.

Two separate samples were taken at all times. One was preserved with copper sulfate for phenol determination and the other sample was used for the remaining analyses.

4. Presentation of Data and Discussion

Measurements were made of the quantity of waste water coming to Plant 2. Pumping rates were calculated by timing the draw-down of water in the pump pit and correcting for inflow. Readings were taken from a timer on the pump at the beginning and end of each work period. From these data, the flows shown in Table 12 were calculated. The average flow to Plant 2 on the day shift on the days measured was 25,400 gallons while the average total daily flow was 44,200 gallons.

The rate of pumping by the No.1 Pump to the Sediflotor was also measured. The water level in the Sediflotor was first lowered and then the length of time to fill a calculated volume was measured. These results

TABLE 12

GALLONS OF WASTE FLOW TO PLANT 2

Date	8 AM to 4 PM	4 PM to 8 PM	8 PM to 8 AM	Daily Total
May 27	29,700	1,500	19,800	51,000
May 28	24,400	5,300	13,700	43,400
May 29	26,700	3,800	-	-
May 31	18,300	3,000	-	-
June 3	28,200	5,300	9,900	43,400
June 4	25,200	2,300	-	-
June 17	24,800	8,300	9,700	42,800
June 18	20,000	4,800	13,800	38,600
June 19	25,500	4,100	16,600	46,200
June 20	31,000	-	-	-

are as follows:

Date	Flow, G.P.M.
5/17/57	71.2
5/23/57	66.0
6/4/57	68.6
6/10/57	67.2

This is an average of 68.2 G.P.M.

With this measured rate of flow, Plant 2 can process 32,700 gallons of wastes through the Sediflotor during an eight hour period. The highest flow coming to Plant 2 occurs during the day shift and the greatest flow measured on the day shift during the survey was 31,000 gallons. Thus it is apparent that Plant 2 is not overloaded hydraulically during the week days with present quantities of flow. Even higher flows on the day shift than those encountered during the survey could be handled by drawing down the level sufficiently in the equalizing tank, on the second shift. At the present time it is necessary to operate Plant 2 only about four hours on the second shift to keep up with the daily incoming flow.

Flows coming to Plant 2 over a week end are sometimes greater than the plant storage capacity. The present equalizing tank has a capacity of 37,700 gallons. On the two week ends during which measurements were made, this capacity was exceeded. From 8 PM May 17 to 8 AM May 20, 50,300 gallons were received. From 8 PM June 14 to 8 AM June 17, 42,100 gallons were received. When the holding tank capacity is exceeded, the wastes flow to Magpie Creek untreated. In order to remedy this situation in the future, an operator will

be on duty at Plant 1 over the week end during the day shift and he can start up Plant 2 if necessary to take care of excessive flow.

The purpose of Plant 2, as with Plant 1, is to remove oils and suspended solids. Performance tests were made at Plant 2 on nine different days. The main objective in these tests was to determine oil removal with different conditions of chemical feed to the Sediflotor. A variation of the influent wastes also influenced the tests. Results of these performance tests are presented in Tables 13 through 21. Table 22 summarizes the analytical results obtained at Plant 2..

The concentration of oil is much greater in the Plant 2 influent than in the wastes coming to Plant 1. A large portion of this oil is free oil and separates in the holding tank. An average oil reduction of 73.8 per cent in the holding tank was experienced on the days that samples were taken, leaving an average concentration of 77 ppm in the Sediflotor influent.

The holding tank acts as a reservoir for the Sediflotor and the waste level in the tank continually changes. Periodically, when sufficient oil accumulates, the level is allowed to rise so that the top portion of the liquid overflows into the skimming trough. This method of skimming is used because the skimming blades on the tank do not function properly.

During the May 23 test, the surface level of the holding tank was allowed to drop to within several inches of the outlet. This increased the oil loading on the Sediflotor since the concentration of oil increased as the surface was approached. The floc was very thin during this test with the result that the Sediflotor was unable to remove much oil and a very high oil concentration was contained in the effluent. Part of the floc carried

TABLE 13

PLANT 2 PERFORMANCE TEST - MAY 16, 1957

	Oil ppm	Phenol ppb	pH	Total Alkalinity ppm
Holding tank in	265	52	10.1	350
Sediflotor in	55	37	10.0	230
Sediflotor out	20	37	10.0	110
Holding tank removal, %	79.3	28.9		
Sediflotor removal, %	63.6	-		

Flow through Sediflotor, gal/min	71.2
Flow, gal/min/ft^2	1.92
Alum added in Sediflotor, ppm as $Al_2(SO_4)_3$	120
Lime added in Sediflotor, ppm as $CaCO_3$	262
PPM alkalinity consumed by alum theoretically	105
PPM alkalinity consumed as found by chemical test and lime consumption	382

Nature of floc: Very thin

TABLE 14

PLANT 2 PERFORMANCE TEST - MAY 17, 1957

	Oil ppm	Phenol ppb	pH	Total Alkalinity ppm
Holding tank in	668	38	7.0	151
Sediflotor in	79	25	8.6	172
Sediflotor out	20	19	7.5	178
Holding tank removal, %	88.2	34.2		
Sediflotor removal, %	74.6	24.0		

Flow through Sediflotor, gal/min	71.2
Flow, gal/min/ft^2	1.92
Alum added in Sediflotor, ppm as $Al_2(SO_4)_3$	164
Lime added in Sediflotor, ppm as $CaCO_3$	262
PPM alkalinity consumed by alum theoretically	144
PPM alkalinity consumed as found by chemical test and lime consumption	256

Nature of floc: Very thin

TABLE 15

PLANT 2 PERFORMANCE TEST - MAY 20, 1957

	Oil ppm	Phenol ppb	pH	Total Alkalinity ppm
Holding tank in	110	45	8.0	119
Sediflotor in	70	45	7.5	110
Sediflotor out	17	19	6.8	58
Holding tank removal, %	36.4	-		
Sediflotor removal, %	75.7	57.7		

Flow through Sediflotor, gal/min	71.2
Flow, gal/min/ft^2	1.92
Alum added in Sediflotor, ppm as $Al_2(SO_4)_3$	244
Lime added in Sediflotor, ppm as $CaCO_3$	200
PPM alkalinity consumed by alum theoretically	214
PPM alkalinity consumed as found by chemical test and lime consumption	252

Nature of floc: Very thick

TABLE 16

PLANT 2 PERFORMANCE TEST - MAY 23, 1957

	Oil ppm	Phenol ppb	pH	Total Alkalinity ppm
Holding tank in	725	90	7.5	154
Sediflotor in	147	81	7.3	143
Sediflotor out	93	74	5.0	8
Holding tank removal, %	79.7	10.0		
Sediflotor removal, %	36.7	8.6		

Flow through Sediflotor, gal/min	66.0
Flow, gal/min/ft^2	1.78
Alum added in Sediflotor, ppm as $Al_2(SO_4)_3$	224
Lime added in Sediflotor, ppm as $CaCO_3$	0
PPM alkalinity consumed by alum theoretically	196
PPM alkalinity consumed as found by chemical test	135

Nature of floc: Very thin

TABLE 17

PLANT 2 PERFORMANCE TEST - JUNE 4, 1957

	Oil ppm	Phenol ppb	pH	Total Alkalinity ppm
Holding tank in	168	240	9.4	339
Sediflotor in	95	217	9.2	236
Sediflotor out	69	160	4.8	3
Holding tank removal, %	43.5	9.6		
Sediflotor removal, %	27.4	26.2		

Flow through Sediflotor, gal/min	68.6
Flow, gal/min/ft^2	1.85
Alum added in Sediflotor, ppm as $Al_2(SO_4)_3$	665
Lime added in Sediflotor, ppm as $CaCO_3$	1080
PPM alkalinity consumed by alum theoretically	584
PPM alkalinity consumed as found by chemical test and lime consumption	1313

Nature of floc: Thin during first portion of test. Then very thick.

TABLE 18

PLANT 2 PERFORMANCE TEST - JUNE 10, 1957

	Oil ppm	Phenol ppb	pH	Total Alkalinity ppm
Holding tank in	782	75	7.2	135
Sediflotor in	84	58	7.3	124
Sediflotor out	29	41	6.6	31
Holding tank removal, %	89.2	22.7		
Sediflotor removal, %	65.5	29.3		
Flow through Sediflotor, gal/min				67.2
Flow, gal/min/ft^2				1.82
Alum added in Sediflotor, ppm as $Al_2(SO_4)_3$				252
Lime added in Sediflotor, ppm as $CaCo_3$				240
PPM alkalinity consumed by alum theoretically				221
PPM alkalinity consumed as found by chemical test and lime consumption				333

Nature of floc: Very thick

TABLE 19

PLANT 2 PERFORMANCE TEST - JUNE 18, 1957

	Oil ppm	Phenol ppb	pH	Total Alkalinity ppm
Holding tank in	430	89	7.7	139
Sediflotor in	44	83	7.8	131
Sediflotor out	14	68	6.9	61
Holding tank removal, %	89.8	6.7		
Sediflotor removal, %	68.2	18.1		

Flow through Sediflotor, gal/min	68
Flow, gal/min/ft^2	1.84
Alum added in Sediflotor, ppm as $Al_2(SO_4)_3$	220
Lime added in Sediflotor, ppm as $CaCO_3$	270
PPM alkalinity consumed by alum theoretically	193
PPM alkalinity consumed as found by chemical test and lime consumption	340
$CaCL_2$ added to Plant 2 influent, PPM	1080

Nature of floc: Very thick

TABLE 20

PLANT 2 PERFORMANCE TEST - JUNE 19, 1957

	Oil ppm	Phenol ppb	pH	Total Alkalinity ppm
Holding tank in	271	99	7.6	130
Sediflotor in	62	86	7.4	122
Sediflotor out	12	67	6.9	65
Holding tank removal, %	77.1	13.1		
Sediflotor removal, %	80.7	22.1		

Flow through Sediflotor, gal/min	68
Flow, gal/min/ft^2	1.84
Alum added in Sediflotor, ppm as $Al_2(SO_4)_3$	220
Lime added in Sediflotor, ppm as $CaCO_3$	270
PPM alkalinity consumed by alum theoretically	193
PPM alkalinity consumed as found by chemical test and lime consumption	327
$CaCl_2$ added to Plant 2 influent, ppm	847

Nature of floc: Very thick

TABLE 21

PLANT 2 PERFORMANCE TEST - JUNE 20, 1957

	Oil ppm	Phenol ppb	pH	Total Alkalinity ppm	Chloride ppm
Holding tank in	288	72	7.3	116	
Sediflotor in	54	53	7.4	116	
Sediflotor out	22	49	7.6	91	93
Holding tank removal, %	81.3	26.4			
Sediflotor removal, %	89.3	7.5			

Flow through Sediflotor, gal/min	68
Flow, gal/min/ft^2	1.84
Alum added in Sediflotor, ppm as $Al_2(SO_4)_3$	220
Lime added in Sediflotor, ppm as $CaCO_3$	270
PPM alkalinity consumed by alum theoretically	193
PPM alkalinity consumed as found by chemical test and lime consumption	295
$CaCl_2$ added to Plant 2 influent, ppm	696

Nature of floc: Very thick

TABLE 22

SUMMARY OF PLANT 2 ANALYSES

	Date	Oil ppm	Phenol ppb	pH	Total Alkalinity, ppm	Cl^- ppm
Influent						
	May 16	265	52	10.1	350	
	May 17	668	38	7.0	151	
	May 20	110	45	8.0	119	
	May 23	725	90	7.5	154	
	June 4	168	240	9.4	339	
	June 10	782	75	7.2	135	
	June 18	430	89	7.7	139	
	June 19	271	99	7.6	130	
	June 20	288	72	7.3	116	
Sediflotor in						
	May 16	55	37	10.0	230	
	May 17	79	25	8.6	172	
	May 20	70	45	7.5	110	
	May 23	147	81	7.3	143	
	June 4	95	217	9.2	236	
	June 10	84	58	7.3	124	
	June 18	44	83	7.8	131	
	June 19	62	86	7.4	122	
	June 20	54	53	7.4	116	
Sediflotor out						
	May 16	20	37	10.0	110	
	May 17	20	19	7.5	178	
	May 20	16	12	6.8	58	
	May 23	93	74	5.0	8	
	June 4	69	160	4.8	3	
	June 10	29	41	6.6	31	
	June 18	14	68	6.9	61	
	June 19	12	67	6.9	65	
	June 20	22	49	7.6	91	93

over into the effluent. The thin floc was probably due, in part, to the fact that lime was not added on this day. Care should be taken that the waste level in the holding tank is not permitted to get sufficiently low that the concentrated oily wastes are pumped to the Sediflotor. With a better quality influent to the Sediflotor, a better quality effluent can be expected.

On June 4 a batch of "Depaint" was dumped into the sewer system with the result that the floc in the Plant 2 Sediflotor was destroyed. Substantial quantities of chemicals were added before a floc was again obtained. The phenol content was very high throughout the system and may be due to an ingredient in the "Depaint" or to the coatings removed from the airplane parts. This point should be checked. A greenish-yellow color was apparent in the wastes on this day. It was suspected that this color was due to hexavalent chromium in the waste. Ferrous sulfate was added to the lime tank and, when this chemical was pumped to the Sediflotor, the color was removed.

The cleaning area near Building 655 uses four barrels, containing 53 gallons each, of gunk each week. Gunk forms very stable emulsions and the ratio of gunk to total flow coming to Plant 2 is much greater than in Plant 1.

A report written by the U. S. Public Health Service for the U. S. Air Force in December, 1955, entitled "Disposal of Airplane Wash Wastes" states that calcium chloride is very effective for breaking emulsions formed by gunk. Gunk is in essence a crude liquid soap that will undergo typical soap reactions with either acid or hardness elements to form an insoluble curd which floats to the surface. Calcium chloride will react with the gunk and break the emulsions without affecting the pH.

Special performance tests were set up on June 18, 19 and 20. During

these tests a calcium chloride solution was added to the waste as it entered the holding tank. The flow of this solution was regulated to give at least 1.4 pounds of calcium chloride per gallon of gunk. Assumptions were made that the gunk was used only on the day shift and that the average weekly usage was spread evenly over the week. Results from these tests show that the concentration of oil in the waste pumped to the Sediflotor was generally lower than the oil concentration in waste not containing calcium chloride. This resulted in a smaller load on the Sediflotor as more oil separated in the holding tank. Plant 2 met the Base specifications for oil on two of the three days during which calcium chloride was used. On the third day the effluent was just 2 ppm above specifications. Effluent chlorides in the one sample examined were well within limits.

Although the trend showed that better results were obtained when calcium chloride was used, it is felt that additional tests are necessary at the Base with actual plant wastes under a wider variety of influent conditions, before definite conclusions are drawn regarding the continuous use of this chemical. Results obtained can be applied at Plant 1 in addition to Plant 2.

Plant 2 has a very small flow compared to the total volume of Magpie Creek. As a result, the total weight of oil and phenol discharged during the hours of operation is relatively small when the plant is functioning properly. The quantities of contaminants discharged during the test period, along with the per cent removal, are shown in Table 23.

TABLE 23

SUMMARY OF CONTAMINANTS REMOVED IN PLANT 2

Date	Influent, lb/hr*		Effluent, lb/hr		% Removal	
	Oil	Phenol	Oil	Phenol	Oil	Phenol
May 16	9.43	.0019	0.71	.0013	92.5	31.5
May 17	23.80	.0014	0.71	.0007	97.0	50.0
May 20	3.92	.0016	0.57	.0004	85.5	75.0
May 23	23.94	.0030	3.07	.0024	87.3	20.0
June 4	5.76	.0082	2.37	.0055	58.8	32.9
June 10	26.30	.0025	0.98	.0014	96.2	44.0
June 18	14.62	.0030	0.48	.0023	96.7	23.3
June 19	9.21	.0034	0.41	.0023	95.5	32.3
June 20	9.80	.0024	0.75	.0017	92.3	29.3

* In calculations, flow into Plant 2 assumed to be the same as the effluent flow.

Although the quantity of oil in the Plant 2 effluent is not large under normal conditions, it could be reduced with a small plant modification. It is suggested that a swinging elbow, similar to those used in oil refineries, be installed. With this item, oil can be skimmed at any level of water in the tank. If desired, more details can be supplied to McClellan AFB by the Robert A. Taft Sanitary Engineering Center.

INDUSTRIAL PLANT 3

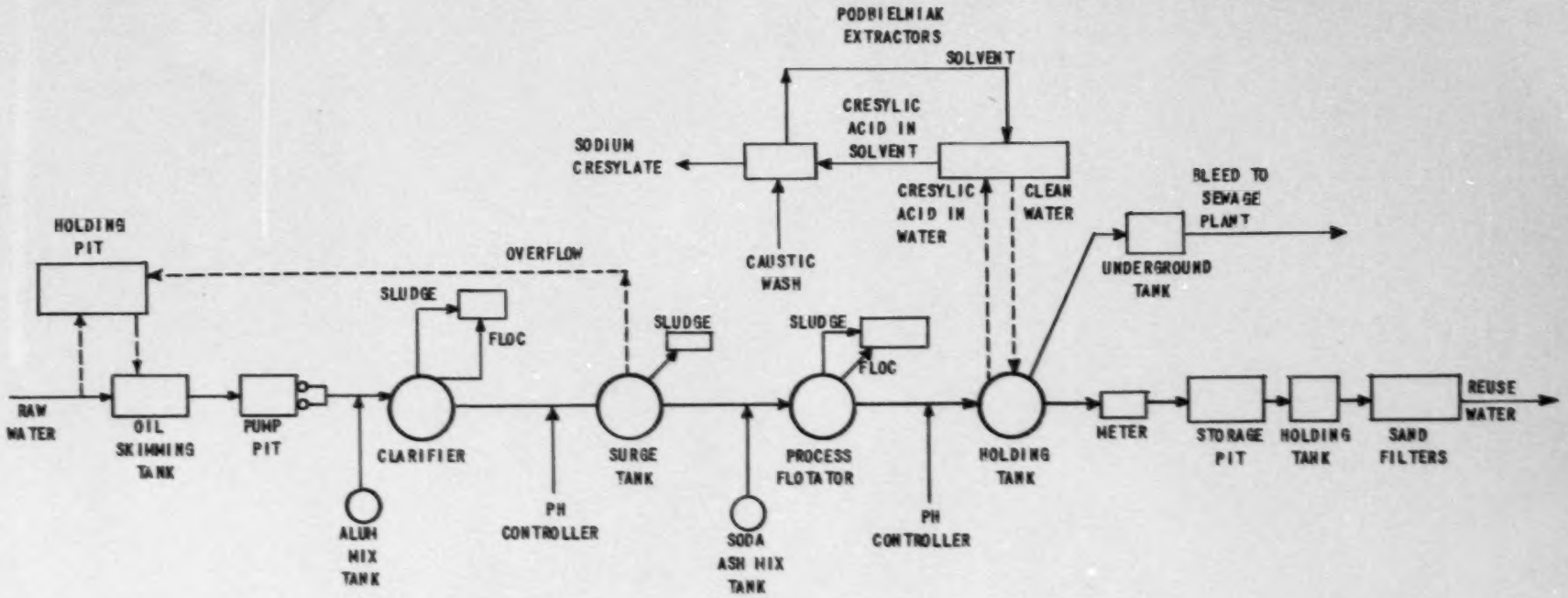
1. Description of Plant

Changes in the Plant 3 process and the type of chemical treatment took place several times during the survey. The process being used at the end of the survey will be described. A flow diagram of this process is shown in Figure 3.

Waste coming from the industrial area flows by gravity to an oil-water separator. This rectangular tank is equipped at the inlet end with a number of parallel, vertical baffles which result in streamlined flow through the tank. Separated oil is pumped to a collecting tank and periodically hauled away for burning. Clarified effluent flows to an adjacent pump pit.

A holding pit, with a capacity of 38,000 gallons, is available to store any excessive flow of raw waste. The inlet pipe to this pit is connected to the raw waste line before the oil-water separator. Waste from the pit can be pumped to the separator or to the adjacent pump pit.

From the pump pit, the wastes are pumped by either of two alternating pumps to a 12,000 gallon clarifier. Alum is added to the line as it enters the clarifier. The alum reacts with the alkalinity in the incoming waste and forms an aluminum hydroxide precipitate. Depending on the density and the quantity of oil adhering to the floc, it either floats on the water surface or settles to the bottom of the clarifier. Provisions are available to skim the water surface and to remove bottom sludge. These materials are collected in a small tank and periodically hauled to a pit on the west side of the Base.



PLANT 3 FLOW DIAGRAM, McCLELLAN AIR FORCE BASE

Figure 3

From the clarifier the wastes flow to a 15,300 gallon surge tank. A pH controller is attached to the clarifier effluent line. The surge tank serves as a reservoir for the Process Flotator. Transfer is made to the Flotator by means of either of two pumps which are used alternately. If additional alkalinity is needed, to give an effluent pH of 7.0, it is added just prior to the Flotator, and is usually added in the form of soda ash.

The principle of the Process Flotator operation is similar to that of the Sediflotor. Air is introduced to the wastes under pressure and then is released in the bottom of the Flotator in the form of tiny bubbles as the pressure is released. The bubbles carry the solid particles and oil to the surface where they are skimmed off. The skimmings and any bottom sludge are collected in a tank and periodically hauled away. The pH of the clarified effluent from the Flotator is continuously recorded. This clarified water flows by gravity to the 60,000 gallon holding tank, from which it flows through a water meter to a 22,000 gallon treated water storage pit. The water is then pumped to a 6,000 gallon holding tank from which it is ready to be pumped to the industrial area as needed. The water passes through two sand polishing filters on the way back to the industrial area.

Water bled from Plant 3 to the Sewage Treatment Plant is drawn from the 60,000 gallon storage tank. This water is held in a tank pending a favorable analysis and then bled at a known rate to the sanitary sewer system.

Although cresylic acid removal is no longer practiced, water can be

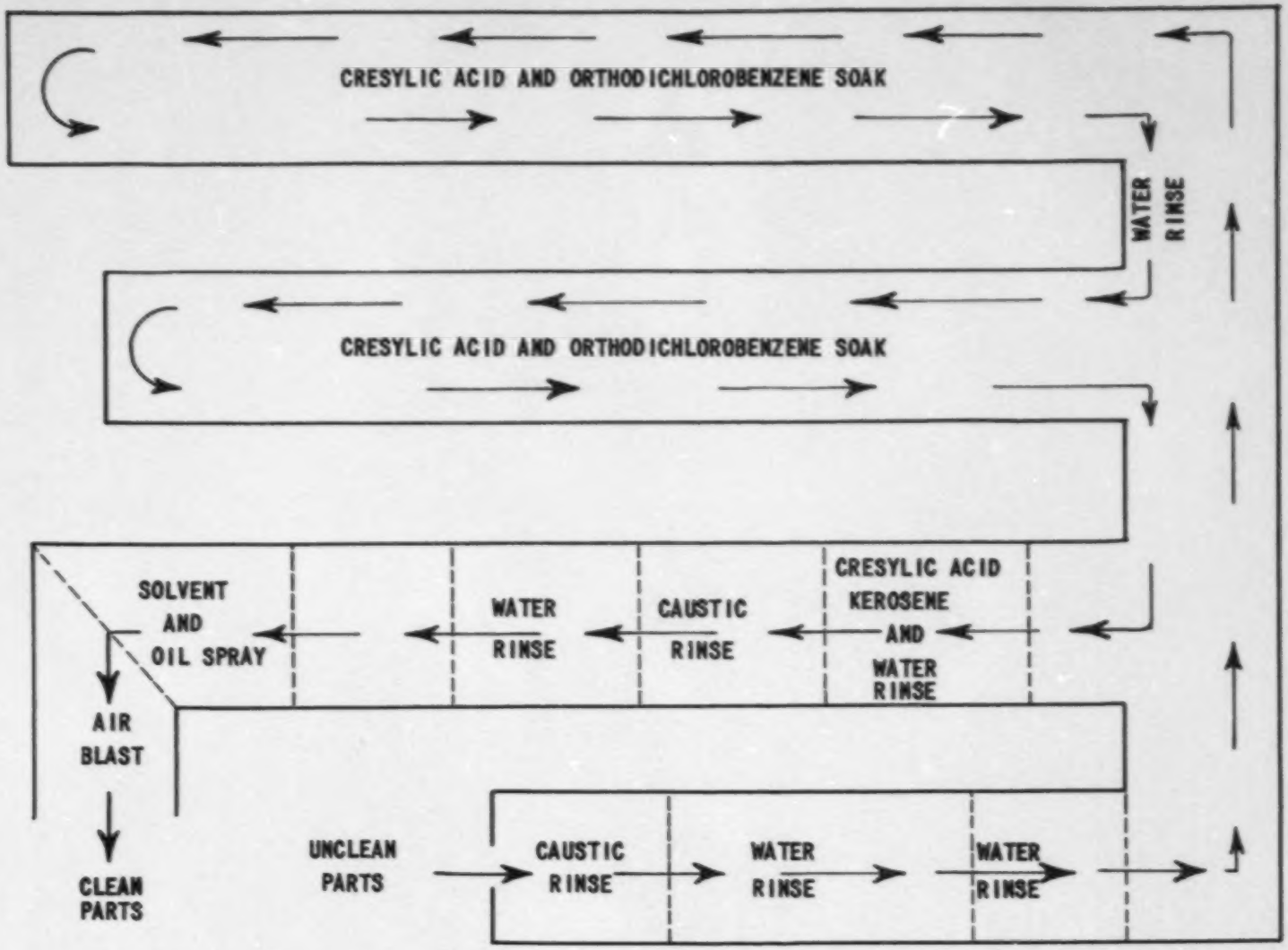
drawn from the 60,000 gallon tank and treated with orthodichlorobenzene in a Podbielniak extractor if it is desired to remove most of the cresylic acid. The water containing cresylic acid flows countercurrent to the solvent within the centrifuge type extractor. The orthodichlorobenzene extracts the cresylic acid and the water is pumped back to the 60,000 gallon tank. Solvent and cresylic acid are pumped to a second Podbielniak extractor and flow countercurrent to a 10% sodium hydroxide solution. The caustic combines with the cresylic acid while the solvent is recycled to the first extractor. Cresol can be regenerated from the sodium cresylate by adding an acid, such as phosphoric, and salting out with sodium chloride.

A summary of the modifications to the Plant 3 treatment process was written by Mr. K. Lind. This summary is reproduced in the Appendix.

2. Source and Description of Wastes

Plant 3 receives its wastes from the engine cleaning area. The main contaminants in the wastes are oil, suspended solids, orthodichlorobenzene and cresylic acid. Most of the oil drains from the airplane engines when they are disassembled. Cresylic acid and orthodichlorobenzene are picked up by the parts in the cleaning operations and removed by the water rinses.

To remove the carbon deposits and clean the engine, the parts travel on a conveyor through a succession of steps. These steps are shown in Figure 4 and are described as follows: (1) a spray with 0.4% sodium hydroxide solution at 180 °F; (2) a fresh water spray at 180 °F; (3) another fresh water spray at 180 °F; (4) a soak in a solution of cresylic acid and orthodichlorobenzene at 150 °F; (5) a fresh water spray at 145 °F;



INDUSTRIAL WASHER - BUILDING 75D McCLELLAN AIR FORCE BASE
Figure 4

(6) a second soak in a solution of cresylic acid and orthodichlorobenzene at 150° F; (7) a spray with a solution of cresylic acid, kerosene and water at 140° F; (8) a dilute sodium hydroxide spray at 180° F; (9) a fresh water spray at 180° F; (10) a spray of Stoddard solvent and #10 SAE oil; (11) an air blast. All of these operations take place within a hood. The parts pass out of the hood and any remaining carbon is removed by hand brushes and/or Stoddard solvent. All of the water rinses in the above operations flow to Plant 3. In addition, a cold water spray which rinses the oil from the engine after it is removed from the shipping container comes to Plant 3.

3. Samples and Preservation

Samples of the raw water to Plant 3 were taken as the water flowed into the pump pit. There was sufficient turbulence to provide adequate mixing. The oil skimming tank was not yet completed on the days that samples were taken but a portion of the free oil separated in either the old skimming pan or the raw water pit. The remaining samples were taken from stop cocks on the Flotator influent line prior to any addition of alkalinity, the Flotator effluent line and the finished water line. These samples were taken every hour and composited over a 12 hour period. No preservative was added to the sample for phenol determination due to the high cresylic acid concentration.

4. Presentation of Data and Discussion

The engine cleaning area works only two shifts per day and there is a flow to Plant 3 only during these two shifts. Daily flows processed in Plant 3, as indicated by the water meter on the 60,000 gallon holding tank effluent line, are shown in Table 24.

TABLE 24

FLOW THROUGH PLANT 3 WATER METER

Date	Gallons Flow	Date	Gallons Flow
May 27	34,200	June 11	29,000
May 28	36,800	June 12	25,700
May 29	42,500	June 13	17,400
May 31	14,100	June 14	33,900
June 3	49,500	June 17	19,300
June 4	11,900	June 18	36,600
June 5	42,900	June 19	35,900
June 6	34,500	June 20	40,300
June 7	31,500	June 21	28,800
June 10	29,100		

Daily average 31,300 gallons

The raw waste flow to Plant 3 is generally higher than that shown by the water meter. The difference is due in part to the water content in the oil, sludge and floc removals during the processing. Evaporation losses also contribute. Under special circumstances, large quantities of Plant 3 water have been hauled to the Base disposal pit. Since June 14, 1957, the main difference between the raw water flow and the flow through the water meter has been due to the bleed-off to the sewage plant. The water to be bled to the sewage plant is taken from the 60,000 gallon tank effluent prior to entering the water meter. The quantity bled to the sewage plant daily during the survey ranged from about 3,000 gallons to 11,000 gallons with the average being about 5,000 gallons. Water addition through the chemical feed is relatively small.

A timer was installed on the pump taking water from the pump pit and the flow was calculated similarly to that in Plants 1 and 2. Results obtained are included in the following data:

Date	Gallons Raw Water	Gallons Through Meter
June 17	50,500	19,300
June 18	51,400	36,600
June 19	54,200	35,900
June 20	51,400	40,300
June 21	41,700	28,800

Daily fluctuations can result with a change in the amount of water held in process.

On June 17, 1957 the flow of raw water to Plant 3 increased by

approximately 16,000 gallons per day. This occurred as a result of the diversion of about 8,000 gallons of preliminary rinse water and about 8,000 gallons of steam condensate from the engine cleaning area. This flow formerly went to Plant 1 but was diverted to Plant 3 because phenolic materials were found in the rinse water.

Plant 3 appears to have adequate hydraulic capacity to take care of the present flows. The various holding pits and tanks provide flexibility and any substantial increase in waste flow could be handled by increasing the number of operating shifts.

The analytical data obtained at Plant 3 are presented in Table 25. As shown by these results, the quality of the process water was quite variable. This quality was affected by process modifications, type and amount of chemical treatment, waste recycle and many other factors. A description of the various modifications made at Plant 3 prior to and during the survey was written by Mr. Lind. This summary is reproduced in the Appendix and a duplication of the description of changes will not be made in this section.

On June 10, prior to the installation of the large oil-water separator, a large quantity of oil got into the treatment plant system. The oil was more than could be removed by chemical treatment in the existing system and resulted in an effluent containing nearly 2,000 ppm oil. Available information indicated that the trouble resulted from a slug of oil in the Plant 3 influent waste and inadequate operational control on this day at the small oil trap located at the beginning of the process. A combination of recycling of the waste within Plant 3 and hauling of part of the waste to disposal pits on the Base reduced the

TABLE 25

SUMMARY OF PLANT 3 ANALYSES

Date	Oil ppm	Phenols ppm	Suspended Solids ppm	Total Solids ppm	Hardness as $CaCO_3$ ppm	Chloride ppm	pH	Total Alkalinity ppm
Plant 3 influent								
May 27	514	619	708	6200	180	126	6.7	422
May 28	1224	613	410	5563	325	116	6.3	-
May 29	2692	816	974	5982	250	121	6.3	306
May 31	480	773	444	6054	235	145	6.3	284
June 17	106	371	282	3378	80	57	8.3	338
June 18	88	493	148	3492	200	61	8.9	352
June 19	56	496	438	4226	125	69	8.5	346
June 20	42	540	182	4104	50	79	9.0	306
Flotator influent								
May 27	88		354				4.8	20
May 28	235		490				5.8	117
May 29	436		442				3.8	0
May 31	148		606				5.9	150
June 17	56		204				6.0	64
June 18	64		164				7.0	155
June 19	47		386				4.3	0
June 20	19		114				5.1	24

TABLE 25 (Con't.)

SUMMARY OF PLANT 3 ANALYSES

Date	Oil ppm	Phenols ppm	Suspended Solids ppm	Total Solids ppm	Hardness as $CaCO_3$ ppm	Chloride ppm	pH	Alkalinity ppm
Flotator effluent								
May 27	67		172				4.3	0
May 28	123		434				5.8	123
May 29	154		272				3.6	0
May 31	75		282				7.3	1225
June 12	350							
June 13	10							
June 17	28		115				6.8	148
June 18	17		98				7.2	169
June 19	7		18				7.4	120
June 20	9		20				7.0	94
Plant 3 effluent								
May 27	16	719	3	5680	460	120	5.9	140
May 28	56	649	9	5894	525	127	5.9	-
May 29	629	663	22	5733	450	121	5.8	248
May 31	74	660	29	5823	425	140	5.9	171
June 10	1920							
June 12	235							
June 13	46							
June 14	33							
June 17	9	367	19	3912	185	73	7.1	260
June 18	13	477	30	4317	135	78	7.0	215
June 19	11	455	34	3785	125	59	7.2	178
June 20	8	496	32	4064	100	73	7.2	168

oil content to satisfactory levels as is shown by the data.

Data on the Flotator efficiencies and chemical addition to the Plant 3 system are shown in Tables 26 and 27 respectively. The Flotator efficiencies were not as great as would be expected with this type of equipment. This can be attributed to the method of operation. There were only two mixing tanks available and these were used at the beginning of the survey to add chemicals prior to the clarifier. Alkalinity in the waste was usually low or absent entirely because phosphoric acid was added to aid in breaking emulsions. Means were not available to add alkalinity at the Flotator and hence, no floc was formed in this equipment. Any separation in the Flotator was due to a physical process with the air bubbles acting similar to an upward moving fine screen.

When the addition of clay was discontinued, a mixing tank became available for adding alkaline materials at the Flotator. Soda ash was used except when the supply was exhausted and caustic soda had to be substituted. Sufficient soda ash was added to give a pH of 7.0 at the Flotator effluent. Alum was added prior to the clarifier and any remaining in the waste at the Flotator reacted with the alkalinity to form a floc. The amount of floc then depends on the alum carry-over. Since the water is recycled to the engine cleaning area, complete removal of the alum is desired by the operators.

TABLE 26

REMOVAL OF OIL AND SOLIDS IN PLANT 3 FLOTATOR

Date	Oil, ppm		Susp. Solids, ppm		% Removal	
	In	Out	In	Out	Oil	Susp. Solids
May 27	88	67	354	172	23.9	51.4
May 28	235	123	490	434	47.7	11.4
May 29	436	154	442	272	64.6	38.5
May 31	148	75	606	282	49.3	53.5
June 17	56	28	204	115	50.0	43.6
June 18	64	17	164	98	73.5	40.2
June 19	47	7	386	18	85.1	95.4
June 20	19	9	114	20	52.6	82.5

TABLE 27

CONCENTRATION OF CHEMICALS ADDED TO PLANT 3*

Date	Alum ppm	Clay ppm	70% H_3PO_4 ppm	Soda Ash ppm	Caustic Soda ppm
May 27	450	2080	240		
May 28	0	1490	240		
May 29	0	1790	240	370	
May 31	0	1190	240	820	
June 17	600				110
June 18	300				110
June 19	2080				130
June 20	600				60

* Based on 42 gal/min. flow to Flotator

Although the Podbielniak extractors were no longer used near the end of the survey, it was decided to obtain personal data on their efficiency in removing phenolic materials. Four runs were made and the data obtained are presented in Table 28. The removal of phenolics averaged 90.7 per cent. Effluent from these extractors would contain more phenolics than could be discharged directly to Magpie Creek.

TABLE 28

REMOVAL OF PHENOLICS IN PODBIELNIAK EXTRACTOR

Date	In ppm	Out ppm	% Removal
June 19 AM	436	12	97.2
June 19 PM	443	25	94.4
June 24 AM	486	51	89.5
June 24 PM	518	94	81.8

It was found during the survey that it was not practical to maintain a completely closed system at Plant 3 for an extended period of time, and still maintain adequate quality in the water recycled to the engine cleaning area. Therefore, a bleed-off of part of the water to the sewage treatment plant was begun on June 14 and proved successful. This bleed-off will be discussed in more detail in a later section.

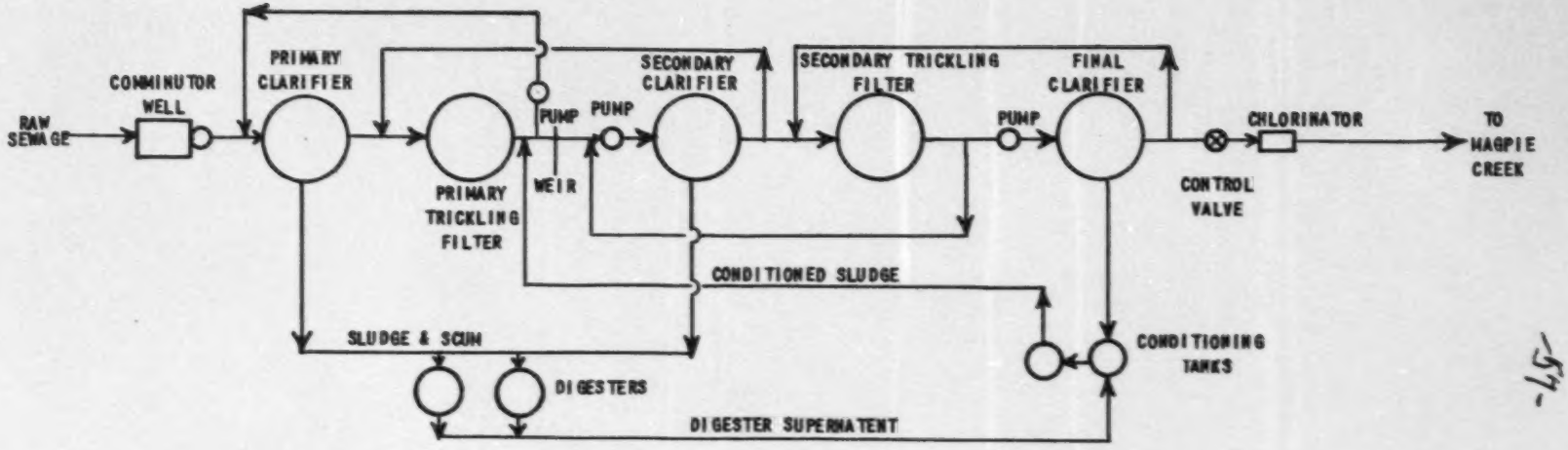
With an adequately sized oil-water separator now in operation to remove most of the free oil, and sufficient experience to determine the best methods for treatment of the waste, it is felt that Plant 3 is capable of producing a good quality effluent. A small bleed-off, together with an introduction of some fresh water, is necessary to prevent contaminants from building up in the system.

SEWAGE TREATMENT PLANT

1. Description and Operation of Plant

Sewage from the Base flows by gravity to a comminutor well, from which it is pumped to the 60 ft. diameter primary clarifier. A sewage plant flow diagram is shown in Figure 5. A portion of the primary trickling filter effluent is recirculated to the primary clarifier influent well, where it combines with the raw sewage. During the survey this recirculated flow was measured as 540 gallons per minute, although it was designed to be approximately 3 times this amount. In the primary clarifier the heavy solids settle to the bottom and the floatable scum rises to the surface where it is skimmed off. The sludge and scum flow to the sludge pump manifold and are pumped to one of the sludge digesters.

Effluent from the primary clarifier flows by gravity to an 80 ft. diameter trickling filter. Here the soluble organic matter of the sewage is used as food for the biological growths on the rocks. The trickling filter effluent flows to the basement of the control house where it flows over a weir. The wastes in back of the weir provide the reservoir for recirculation to the primary clarifier influent. Sewage flowing over the weir combines with a portion of the secondary trickling filter effluent and is pumped to the 60 ft. secondary clarifier. Here, solid materials, including any that sloughs from the trickling filters, are removed. The sludge and scum from the secondary clarifier flow to the sludge pump manifold and are pumped to one of the digesters.



SEWAGE PLANT FLOW DIAGRAM, McCLELLAN AIR FORCE BASE

Figure 5

Wastes flowing from the secondary clarifier split, part returning by gravity to the primary trickling filter influent and the remainder combines with a portion of the final clarifier effluent. This latter water flows to the 80 ft. secondary trickling filter and receives biological treatment. The secondary trickling filter effluent also splits. A portion flows by gravity to the secondary clarifier influent and the remainder is pumped to the 85 ft. diameter final clarifier.

Part of the final clarifier effluent flows to the control house for chlorination and the remainder is recycled to the secondary trickling filter influent. The quantity of water flowing to the chlorinator is controlled by a valve. This valve is actuated by the raw sewage flow so as to permit the plant effluent to have the same flow as the raw sewage. Chlorination of the effluent is routinely practiced and then the water flows to Magpie Creek.

Sludge from the final clarifier and supernatant from the digesters are pumped to two conditioning tanks. Here the material is aerated. After aeration, this conditioned sludge flows to the primary recirculation sump in the control house where it combines with the primary trickling filter effluent.

Solid materials from the primary and secondary clarifiers are pumped to one of two sludge digesters. After an adequate period of digestion, the sludge is pumped to the sludge drying beds.

2. Source of Wastes

Wastes coming to the sewage plant originate at all plant toilet facilities, the Wherry housing project, the barracks, and the Base mess halls. In addition, toward the end of the survey, the sewage plant began to receive a bleed-off from the Plant 3 process water.

3. Samples and Sampling

Samples were taken once per hour and composited on most days over a 24-hour period. On a few of the days the composite was made only over 16 hours because the operator was unable to come to work on one shift. Samples of the raw sewage were taken at a sample cock on the raw sewage line while samples of the clarifier effluents were taken in the channel as the water entered the effluent pipe.

Two separate samples were taken at all times. One was preserved with copper sulfate for phenol analysis and the other sample was used for the remaining determinations.

4. Presentation of Data and Discussion

The flow measurements at the sewage treatment plant were taken at the control house from the recorder that measures raw sewage flow. Some of the values were obtained over 4-hour periods of the day. These values are shown in Table 29.

On June 18 the sewage flow recorder was recalibrated by the Base personnel. This resulted in a reduction of the recorded flow. The average raw sewage flow for the first nine days after recalibration of the recorder was 986,000 gallons per day. Flows from 8:00 AM to 8: 00 PM

TABLE 29

FLOW OF RAW SEWAGE TO THE SEWAGE PLANT
(Thousands of Gallons)

Date	Noon to 4 PM	4 PM to 8 PM	8 PM to 12 Mid.	12 Mid. to 4 AM	4 AM to 8 AM	8 AM to 12 Noon	Total
June 10							1,390
June 11							1,360
June 12	290	250	250	140	160	250	1,340
June 13	250	290	160	140	250	160	1,250
June 14	300	180	210	190	150	190	1,220
June 15	220	220					1,200
June 16							1,230
June 17							1,490
June 18	230	190	160	170	90	210	1,050*
June 19	170	210	230	90	140	200	1,040
June 20	190	190	160	100	160	200	1,000
June 21							910
June 22							810
June 23							950
June 24	210	190	170	120	140	210	1,040
June 25							1,030
June 26							1,040

* Recorder recalibrated

appear to be relatively constant while the low flow period occurs between midnight and 4:00 AM.

Consideration of the flow applied to the sewage plant units indicates that the sewage plant is not overloaded hydraulically.

Analytical data obtained at the sewage treatment plant are presented in Table 30. The per cent reduction of biochemical oxygen demand and phenols within the plant is shown in Table 31. It can be seen that the sewage plant is performing very satisfactorily in treating the sewage.

The average 5-day BOD in the raw sewage was 103 ppm. This is a relatively weak sewage that contains much dilution water. Over-all BOD reduction in the plant was 86.4 per cent and the 14 ppm average BOD in the effluent is comparable to some of the better sewage treatment plants in the country. The McClellan sewage plant would be able to treat additional sewage without any difficulty. The trickling filters can tolerate a stronger sewage and still give a satisfactory effluent. Additional hydraulic loading may reduce the percentage removal of suspended solids in the primary clarifier slightly. However, this would not be a serious problem because of the weak sewage being treated.

Data on the BOD removals at the different stages of the plant indicate that the secondary trickling filter is performing just as good as the primary trickling filter. These results were obtained in spite of the fact that the secondary clarifier influent is diluted by the weaker recycle waste from the secondary trickling filter.

TABLE 30

SUMMARY OF SEWAGE PLANT ANALYSES

Date	BOD ppm	Phenols ppb	Oils ppm
Raw Sewage			
May 31	104	65	
June 3	102	35	
June 5	89	63	
June 6	93	59	
June 14	131	10,270	
June 16	136	5,525	
June 17	99	1,526	
June 18	93	529	
June 19	78	902	
June 20	109	2,677	
June 23		3,209	
June 24		1,890	
June 25		4,800	
Primary Clarifier Effluent			
June 3	34	21	
June 5	51	55	
June 6	57	59	
June 14	86	6,690	4.9
June 16	57	5,176	6.3
June 17	67	1,526	9.5
June 18	49	434	7.0
June 19	46	775	11.0
June 20	65	1,499	

TABLE 30 (Con't.)

SUMMARY OF SEWAGE PLANT ANALYSES

Date	BOD ppm	Phenols ppb	Oils ppm
Secondary Clarifier Effluent			
June 3	35	44	
June 5	29	43	
June 6	29	35	
June 14	37	3,374	
June 16	38	4,509	
June 17	33	631	
June 18	25	168	
June 19	20	204	
June 20	35	468	
Final Clarifier Effluent			
May 31	18	7	
June 3	11	8	
June 5	15	25	
June 6	12	15	
June 14	15	1,438	0.6
June 16	16	1,623	4.1
June 17	18	330	
June 18	12	90	2.0
June 19	9	66	3.0
June 20	15	121	
June 23		54	
June 24		94	
June 25		146	

TABLE 31

PER CENT REDUCTION OF APPLIED CONCENTRATION IN SEWAGE PLANT AT VARIOUS STAGES OF PLANT

Date	Primary Clarifier		Primary Filter & Sec. Clarifier		Secondary Filter & Final Clarifier		Over-all Reduction	
	BOD	Phenol	BOD	Phenol	BOD	Phenol	BOD	Phenol
May 31							82.7	89.2
June 3	66.7	40.0	0	0	68.6	81.8	89.2	77.1
June 5	42.7	12.7	43.1	21.8	48.3	41.9	83.1	60.3
June 6	38.7	0	49.1	40.7	58.6	57.1	87.1	74.6
June 14	34.4	34.9	57.0	50.0	59.5	57.4	88.5	86.0
June 16	58.1	6.3	33.3	12.9	57.9	64.0	88.2	70.6
June 17	32.3	0	50.7	58.7	45.5	47.7	81.8	78.4
June 18	47.3	18.0	49.0	61.3	52.0	46.4	87.1	83.0
June 19	41.0	14.1	56.5	73.7	55.0	67.6	88.5	92.7
June 20	40.4	44.0	46.2	68.8	57.1	74.1	86.2	95.5
June 23								98.3
June 24								95.0
June 25								97.0

The growth on the secondary trickling filter was not as abundant as that on the primary trickling filter. The concentration of sewage applied to the secondary filter is probably too weak to support a greater biological growth.

It has been stated by one person at the Base that the filters were anaerobic because of the black growths on the rocks. This is not the case. Properly designed and operated trickling filters are always aerobic. The fact that the McClellan filters did not give off any noticeable odors showed that these filters were aerobic. Aerobic bacterial growths have a black color, rather than green, because they contain no chlorophyll. These bacterial growths are responsible for most of the treatment taking place on the filter. The green growths on some of the rocks were probably algae.

Data obtained prior to the bleed-off of process water from Plant 3 show that a small amount of phenolic material was being received by the sewage plant. The first several days after the introduction of Plant 3 water, the per cent reduction of phenols was relatively low. However, as the bacterial growths on the trickling filters became acclimated to the phenols, the per cent reduction increased and finally leveled off at 95 to 98 per cent. Information from the Base three weeks after the end of the survey indicated that the reduction of phenols remained at this level when 1,200 ppb were applied to the filters. Up to 10,000 ppb phenol may be applied to the trickling filters, if necessary, with complete safety. However, an increase of applied phenol would also increase the quantity of phenol in the sewage plant effluent, which flows to Magpie Creek.

Data on the concentration of orthodichlorobenzene being received at the sewage plant, from the Plant 3 bleed-off, could not be obtained from the industrial hygiene laboratory prior to the end of the survey. It is known that this chemical is toxic to the growths on the trickling filters. However, with a maximum solubility in water of 145 ppm at 25° C, it would not be possible to approach toxic conditions from orthodichlorobenzene with the present amount of bleed-off from Plant 3.

The Plant 3 bleed-off did not harm the operation of the sewage treatment plant. BOD reductions were not changed and gas production in the digesters was not reduced. However, the application of chlorine was increased to satisfy the small additional chlorine demand.

Reduction in concentration of phenolic material in the primary clarifyer was primarily a result of dilution. A less concentrated waste from the primary trickling filter effluent is recycled and mixes with the raw sewage to give this lower value. BOD reduction in the primary clarifier, however, is a result of both dilution and settling of suspended solids.

The quantity of BOD and phenols discharged to Magpie Creek from the sewage plant is shown in Table 32. BOD is sufficiently low that it can be taken care of by the dilution and natural oxidation in Magpie Creek. Phenol discharged was relatively high during the first several days that the Plant 3 bleed-off took place. However, it was reduced to approximately one pound per day at the end of the survey. If the Plant 3 bleed-off is such that it results in a 1.2 ppm phenol concentration as applied to the trickling filters, and a 97 per cent reduction

is obtained, then only 0.3 lb. per day of phenol would be discharged to the Creek from the sewage plant.

TABLE 32

CONSTITUENTS IN SEWAGE PLANT EFFLUENT

Date	Flow M.G.D.	BOD ppm	BOD lb/day	Phenols ppb	Phenols lb/day
June 14	1.22	15	152	1,438	14.6
June 16	1.23	16	164	1,623	16.6
June 17	1.49	18	224	330	4.1
June 18	1.05*	12	105	90	0.8
June 19	1.04	9	78	66	0.6
June 20	1.00	15	125	121	1.0
June 23	0.95			54	0.4
June 24	1.04			94	0.8
June 25	1.03			146	1.3

* Recorder recalibrated

PHENOLIC TRACING STUDIES

1. Introduction

The data taken at Plants 1 and 2 showed that materials which gave a positive reaction in the 4-aminoantipyrine test for phenol were present in the wastes coming to both plants. Plant 1 received considerably more phenols than Plant 2. In an effort to find out the source of these materials and if a large amount was being discharged from one source or a small amount was being discharged by a number of sources, samples were taken at a number of points throughout the industrial waste sewer system. Qualitative tests were made until the source of contamination was determined. These tests showed order of magnitude values only. The full analysis was then made on the samples from the phenolic source if the qualitative results were significant.

2. Wastes Coming to Plant 1

Data on phenolic concentration in wastes coming to Plant 1 from Pit 40 showed that these wastes contained relatively small amounts of phenolics. It was decided to concentrate on the wastes coming to Pit 41 because the concentration of phenolic materials was quite high, particularly on the day and evening shifts. The results of the qualitative tests and the locations of the sampling points are shown in Table 33. These samples were taken on May 14. An estimate was made of the range in concentrations of the relative value assigned to each sample. These are:

Low	< 1 ppm
Moderate	1-10 ppm
High	10-30 ppm
Very High	> 30 ppm

TABLE 33

CONCENTRATION AND LOCATION OF PHENOLIC SAMPLES
IN PLANT 1 SEWER SYSTEM

Relative Concentration	Location
Not detected	Manhole between Bldg. T330 and Bldg. 74
Not detected	Manhole 7-27 near the north corner of Bldg. 74
High	Manhole 7-17 near Bldg. 75 B
Moderate	Manhole 7-15 near south corner of Bldg. 58
Very high	Manhole 7-14 near north corner of Bldg. 58
High	Line to manhole 7-8 draining Bldg. 73
Moderate	Total flow in manhole 7-8 near Pit 41
Not detected	Manhole 7-2 between Bldg. T343 and T340
Moderate	Effluent from Pit 41 to Plant 1
Not detected	Catch basin at west side of spray pool, Bldg. 59
Very high	Pump Pit 5 draining Bldg. 82 at Plant 3
Very high	Overflow from A series rinse tanks, Bldg. 75 B
Low	Effluent from steam cleaning and Zyglo, Bldg. 75
Very high	First catch basin northeast of Pit 41, draining area outside of Bldg. 73
Not detected	Sump pump discharge northeast of Pit 41 draining Bldg. 73
High	Drainage to Pump Pit 5 during Podbielniak flushing operations at Plant 3
Not detected	Flow through manhole 7-33 to Magpie Creek at 47th and X Streets.
Not detected	Flow through 30 inch storm and industrial waste sewer to Magpie Creek near north corner of high horsepower reciprocating engine test facilities.

A further study of the locations which yielded a sample with a high or very high concentration of phenolic material gave the following information:

Overflow from A series rinse tanks, Bldg. 75B. Wastes from these tanks were found to be contaminated.

Manhole 7-17 near Bldg. 75B. This sample was contaminated by the overflow from the A series rinse tanks.

Line to manhole 7-8 draining Bldg. 73. This sample was contaminated by wastes from other sources that backed up in the drainage line involved.

First catch basin northeast of Pit 41, draining area outside of Bldg. 73. This catch basin is located near the exhausts of the engines being tested. The area is sometimes flushed down and these flushings drain to Pit 41 through the catch basin.

Drainage to Pump Pit 5 during Podbielniak flushing operations at Plant 3. After the Podbielniak extractors were used, they were cleaned out with tap water. The nearby cesspool is connected to the Pit 41 system and the flushings had been draining to this cesspool.

Pump Pit 5 draining Bldg. 82 at Plant 3. This sample contained the Podbielniak flushings and also part of a cresylic acid spill which took place the day before. The spill resulted when the bottom of a tank corroded through. The nearby cesspool drains to Pit 5 and then to Pit 41.

Manhole 7-14 near north corner of Bldg. 58. This sample was contaminated by the cresylic acid spill mentioned above. Part of the concentrated cresylic acid was still in the system.

Three of the samples were analyzed to determine the extent of phenolic contamination. The results are as follows:

Pump Pit 5 draining Bldg. 82	-	671 ppm
Overflow from A tanks, Bldg. 75 B	-	36 ppm
Drainage from Podbielniak flushings	-	11 ppm

After learning of the discharge of phenolic material as a result of the flushing operation, Plant 3 personnel arranged to divert all of the flushing water to the Plant 3 system. Later, the operation of the Podbielniak extractors was discontinued entirely. However, the cesspool in the Podbielniak area is still connected to the Plant 1 sewer system.

Efforts were directed to finding the cause of the contamination in the A series tanks of the engine cleaning area. The first step in cleaning the parts is to spray them with a dilute caustic solution and then rinse them with water. The water is taken from a pool in the tank, sprayed on the parts and then it flows into the pool again. Fresh water is continually added to the tank and the overflow drained off.

This overflow drained to Plant 1 and contained the phenolic material. Since this first rinse took place prior to the immersion of the parts in cresylic acid, it was formerly assumed by Base personnel that this water was not contaminated.

Two lines come from the engine cleaning area to the main sewers of the Pit 41 system. One of these lines drains the wastes from the Zyglo and steam cleaning operations. The other line drains the overflow from all of the A series rinse tanks. Figure 4 shows the location of these rinse tanks in the system. On May 20 an attempt was made to locate the exact source of phenols. Samples obtained and analyses are as follows:

Drain from Zyglo and steam cleaning	-	0.202 ppm
Outside drain from A tanks	-	7.0 ppm
Water in tanks A-2 and A-3	-	2.5 ppm
Water in tank A-4	-	39.5 ppm

It was noticed that droplets of liquid were running down the inside of the hood from the direction of the soak tanks to tank A-4, the last water rinse tank in the first row. The droplets were apparently dripping from the parts as they came out of the water rinse between the two soak tanks. The hood was modified so that the droplets flowed to the Plant 3 sewer system. Samples were again taken on May 23 to determine if this diversion had any effect. The phenol results were as follows:

Water in tank A-4	-	68 ppm
Outside drain from A tanks	-	42 ppm
Outside flow from Zyglo and steam cleaning	-	2.7 ppm
Pit 41 effluent to Plant 1	-	1.6 ppm

Since the difficulty remained unsolved, it was decided to determine the effect that the airplane engine parts had on the contamination of the A series tanks. It was thought possible that phenolic materials could be formed during the combustion of gasoline, and the oil, carbon deposits and the metal parts themselves could be contaminated with phenols. Small quantities of phenols could also originate in lubricating oils. In order to confirm these theories, on May 27, a number of unclean engine parts were washed in an alkaline solution. One gallon of caustic cleaning compound was mixed with 25 gallons of water in a drum. The water was cold rather than at 180 °F as in the tanks. Therefore, our test could not be expected to remove as much of the deposits on the parts as a hot caustic solution. The parts washed are as follows:

28 Valves
16 Adjusting and oiling stems for rocker arms
4 Valve covers
12 Valve retainer clamps
4 Valve rocking arms
1 Cylinder casing
1 Cylinder frame

Phenol analyses obtained for the solution were:

Caustic solution before washing parts - 0.013 ppm
Caustic solution after washing parts - 0.126 ppm

These values showed that some phenols could be picked up by the rinse waters from the parts. Arrangements were then made to take samples the morning of May 29 in tank A-4 before operations began and each hour for two hours. This would indicate the approximate amount of phenolic

materials being picked up from the parts. In addition, several oil screens from an airplane engine were washed and the wash water analyzed for phenol. These screens had previously gone through the entire cleaning operation. It was thought that the oil screens could be a source of high contamination of phenolic materials since these screens are usually recycled through the cleaning process. Cresylic acid picked up during the first cleaning step could be washed out as the screens go through a second time. Analytical results on this day are as follows:

Washings from oil screens - 43 ppm

Tank A-4 water, 7:00 AM - 11 ppm

Tank A-4 water, 8:00 AM - 29 ppm

Tank A-4 water, 9:00 AM - 31 ppm

The oil screens were shown to be one source of phenolic contamination. Rinse water in tank A-4 picked up phenols as engine parts were processed through it. However, the 7:00 AM sample was higher than expected. Fresh water was put in the tank at 11:00 PM the previous evening and this water had been in the tank for 8 hours before the sample was taken. It was thought that oils and sludges in the tank could have contaminated the water over night. Therefore, the test was repeated on May 31. The tank was drained and cleaned. Fresh water was put in at 7:00 AM and a sample was taken. Additional samples were taken after the engine parts had been processed. These analyses are as follows:

Tank A-4 water 7:00 AM - 0.81 ppm

Tank A-4 water 8:00 AM - 19 ppm

Tank A-4 water 10:00 AM - 44 ppm

Thus, it seems that the parts contribute to the phenolic contamination.

Another possible source of phenolic contamination is from the exhaust ventilation system. The vapors from the entire cleaning process are drawn through the hoods to the atmosphere. The exhaust to the atmosphere is located above the A series tanks. As the water vapors from the A tanks condense on the walls of the hood and the droplets flow back into the tank, these droplets could absorb phenolic materials from the passing vapors from the soak tanks.

It was thought that the best way to prevent these phenolic materials from being discharged to Magpie Creek through Plant 1 was to divert them to Plant 3. Here they would be recycled with the other phenolic wastes. Accordingly, appropriate changes were made in the engine cleaning area and the overflow from the A tanks was diverted to Plant 3 starting June 17. Approximately 16,000 gallons per day were diverted, including steam condensates from the area.

3. Wastes Coming to Plant 2

A study was made on wastes in the Plant 2 sewer system similar to the study made for Plant 1. The results obtained on May 15 are presented in Table 34. Estimates for the relative concentrations are the same as the estimates made for Plant 1. Two of these samples were analyzed to obtain the exact phenolic concentration. The results are as follows:

Manhole at northwest corner of wash rack	- 0.27 ppm
Line draining Bldg. 88	- 0.04 ppm

Most of the phenols coming to Plant 2, therefore, originate at the wash rack. The phenols probably are contained in the oils, greases, or coatings washed from the airplane sections. If this is the case, very little can be done to eliminate the contamination. However, the quantity of phenolics is small and contribute very little to the over-all amount leaving the Base.

TABLE 34

CONCENTRATION AND LOCATION OF PHENOLIC SAMPLES
IN PLANT 2 SEWER SYSTEM

Relative Concentration	Location
Low	Manhole 11-6 at northwest corner of wash rack at Bldg. 658.
Not detected	Pump No. 8 in manhole at northeast corner of Bldg. 655.
Not detected	Storm sewer at manhole at southeast corner of Bldg. 655.
Not detected	Flow to Plant 2 from area south of this plant.
Low	Flow from Plant 2 to Magpie Creek.
Low	Manhole north of Bldg. 88 for line draining this building.

MAGPIE CREEK

1. Introduction

Magpie Creek drains the area northeast of McClellan Air Force Base and, after passing through the Base, discharges into Natomas East Main Drainage Canal. This water then flows to the Sacramento River. The Sacramento water intake is located in the Sacramento River just below confluence with the American River. Past taste and odor difficulties in the water supply have been attributed to McClellan AFB.

Above the Base, Magpie Creek receives the effluent from the Camp Kohler Sewage Plant. Secondary treatment is provided by the plant. Other than run-off from rainfall, the sewage plant effluent constitutes the main flow until the creek enters McClellan Field. Camp Kohler laundry, which is operated by the Air Force, discharges about 85,000 gallons of wastes per day to this sewage plant.

During the winter season, considerable dilution is provided by rainfall. However, during the remainder of the year, the area is relatively dry.

2. Samples and Preservation

Samples from Magpie Creek at the Base effluent were composite samples. Prior to June 1 these samples were taken by means of an air release type of sampler that was not always reliable. During June all effluent samples were taken by means of a sample pump.

Magpie Creek samples taken at the Base influent prior to the middle of June were grab samples. They were taken at approximately 4:30 PM

each day. During the last two weeks of the survey, these samples were taken by means of the air release sampler that was moved from the Base effluent.

The samples received no preservation prior to May 9. However, after this date, all samples were preserved with copper sulfate.

3. Presentation of Data and Discussion

The flow of Magpie Creek as it enters McClellan Air Force Base is shown in Table 35. These measurements were made by means of a 90 degree V-notch weir and a continuous water level recorder. On several days the instantaneous flow was so great that the water went over the top of the weir. This usually happened after a hard rain or when the Base swimming pool was emptied. On the days that the flow did not exceed the top of the weir, the average influent flow was 1.17 million gallons per day.

Magpie Creek receives the industrial and sewage plant discharges as it crosses the Base. Just before leaving the Base, the creek is diverted through a Parshall flume and an oil skimming basin. In case of a heavy rain, a gate is closed and the creek will by-pass the flume and skimming basin.

Calculated flows for the volume of water passing through the Parshall flume during the survey are presented in Table 36. The flows calculated from the readings on the recorder charts were multiplied by 1.25 to obtain the values in the table. It is felt that these values are more representative of actual conditions. On three occasions, discharge measurements were made with a current meter for the water

TABLE 35

MAGPIE CREEK FLOW - McCLELLAN INFLUENT

Date 1957	Flow M.G.D.	Date 1957	Flow M.G.D.
April 29	1.26	May 26	>1.29
April 30	1.16	May 27	>1.37
May 1	1.11	May 28	1.23
May 2	1.28	May 29	1.11
May 3	1.16	May 30	1.01
May 4	1.18	May 31	1.23
May 5	1.19	June 1	1.11
May 6	>1.46	June 2	>1.28
May 7	1.09	June 3	1.36
May 8	1.18	June 4	1.39
May 9	1.06	June 5	1.33
May 10	1.11	June 6	1.27
May 11	1.00	June 7	1.25
May 12	0.95	June 8	1.07
May 13	1.11	June 9	>1.19
May 14	>1.57	June 10	1.22
May 15	1.10	June 11	1.18
May 16	1.16	June 12	1.23
May 17	1.12	June 13	1.12
May 18	-	June 14	1.14
May 19	1.32	June 15	1.01
May 20	-	June 16	0.97
May 21	1.54	June 17	>1.42
May 22	1.11	June 18	1.23
May 23	1.16	June 19	-
May 24	1.15	June 20	1.12
May 25	1.11	June 21	>1.37

TABLE 36

MAGPIE CREEK FLOW - McCLELLAN EFFLUENT

Date 1957	Flow* M.G.D.	Date 1957	Flow* M.G.D.
May 1	3.8	May 28	4.2
May 2	4.7	May 29	3.8
May 3	3.8	May 30	1.8
May 4	2.2	May 31	3.4
May 5	2.2	June 1	2.0
May 6	4.2	June 2	2.3
May 7	3.9	June 3	4.1
May 8	4.5	June 4	4.5
May 9	3.4	June 5	4.5
May 10	3.7	June 12	4.2
May 11	2.0	June 13	4.2
May 12	1.8	June 14	4.4
May 13	3.7	June 15	2.0
May 14	4.2	June 16	2.0
May 15	3.8	June 17	4.5
May 16	4.0	June 18	4.8
May 17	3.9	June 19	5.0
May 23	3.7	June 20	4.5
May 24	3.7	June 21	4.8
May 25	2.0	June 22	2.7
May 26	2.1	June 23	2.7
May 27	3.8		

* The recorded flow was multiplied by a factor of 1.25 to obtain the above values.

flowing in the channel leading to the Parshall flume. The measurements were far enough upstream that they were not affected by the flume. These data were compared to the Parshall flume discharge as recorded at the same time. The comparison is as follows:

Date	Meter flow cfs.	Flume flow cfs.	Difference cfs.	Ratio Meter / Flume	Type of flow
May 10	7.49	6.20	1.29	1.21	Submerged
May 28	8.76	6.76	2.00	1.30	Submerged
June 12	8.25	6.44	1.81	1.28	Free

A correction factor of 1.25 was picked as being most representative to use with the recorded Parshall flume flow. The cause for the flume readings being in error could not be determined as the dimensions of the flume met standard specifications. Backwater from the skimming basin caused the flume to be submerged but current meter readings during temporary free flow conditions resulted in similar values. Free flow was obtained by removing the flood gates from the skimming basin. The Betz Consulting Engineers indicate in a 1952 report that the McClellan Parshall flume was giving a lower than actual flow at that time also.

The average flow during the month of May at the Base effluent was 3.9 M.G.D. on the working days. On working days in June the average flow increased to 4.5 M.G.D. due mainly to the increased use of cooling water on the Base as warmer weather arrived.

In addition to the discharges from the waste treatment plants previously discussed, there is a flow from the engine test blocks directly to Magpie Creek. This water is used for cooling purposes.

Samples for phenol analysis were taken on each work day at the Base influent and effluent. These samples were analyzed by the McClellan Industrial Hygiene Laboratory and collection began prior to the Public Health Service survey. Periodically, duplicate samples were taken and the second sample was analyzed by the Public Health Service. The results of these analyses are presented in Table 37.

As seen in this table, there is a definite downward trend in the concentration of phenolic materials leaving the Base. The average of March samples was 136 ppb; April, 98 ppb; May 46 ppb and June, 40 ppb. A July 15 communication from McClellan stated that the effluent remained below 25 ppb during the last week of June and the first two weeks of July. Thus a definite improvement has been made in the quality of the Base effluent.

Average values for samples taken at the Base influent are as follows: March, 26 ppb; April, 44 ppb; May, 29 ppb and June, 27 ppb.

The phenols leaving the Base have been converted to pounds for an 8 day period near the end of the survey. These data are shown in Table 38. The average quantity of phenols leaving the Base during the 8 days was 1.5 pounds per day. A concentration of 25 ppb or less, the values reported immediately after the survey ended, would result in less than one pound per day of phenols leaving the Base. An approximation of the origin of this one pound per day of phenols would be as follows: Magpie Creek influent, 0.25 pounds; Plant 1, 0.43 pounds; Plant 2, 0.02 pounds; Sewage Plant, 0.30 pounds. The latest analytical data available were used in these estimates.

TABLE 37

MAGPIE CREEK PHENOL ANALYSES

Date 1957	Base Influent AF Phenol ppb	Base Effluent AF Phenol ppb	Date 1957	Base Influent AF Phenol ppb	Base Influent PHS Phenol ppb	Base Effluent AF Phenol ppb	Base Effluent PHS Phenol ppb
March 22	13	44	May 7	-		60	17
25	11	63	8	0		10	163
26	9	240	9	18		12	
27	46	23	10	120		40	
28	32	276	13	0		22	
29	44	172	14	106		220	
April 1	0	294	15	8	0	43	30
2	0	34	16	16		70	
3	272	91	17	40		70	
4	72	98	20	0		12	
5	36	0	21	49		65	
8	24	52	22	21		48	
9	16	218	23	42		73	33
10	48	18	24	37		43	
11	6	250	27	38		45	
12	60	20	28	15		23	
16	0	102	29	0		30	
18	26	32	31	16		5	
19	0	44	June 3	0		29	
22	48	128	4	67		20	
26	40	42	5	76	16	111	101
29	0	28	6	28		11	
30	108	210	7	41		92	
May 1	0	42	10	0		3	
2	40	26	11	18	5	24	36
3	34	30	12	0		11	
6	0	32	13	7		21	
			14	35		37	
			17	46		63	
			18	2		20	
			19	30		34	
			20	20		44	
			21	48		88	
			24	12		26	

TABLE 38

QUANTITY OF PHENOL IN MAGPIE CREEK AT McCLELLAN EFFLUENT

Date 1957	Flow M.G.D.	Phenol ppb	Phenol lb/day
June 12	4.2	11	0.4
June 13	4.2	21	0.7
June 14	4.4	37	1.4
June 17	4.5	63	2.4
June 18	4.8	20	0.8
June 19	5.0	34	1.4
June 20	4.5	44	1.7
June 21	4.8	88	3.5

On several days, samples were taken of Magpie Creek water downstream from the Base. June 6 a sample taken from the creek at 16th Street showed a phenol content of 14 ppb. Two samples were obtained from Natamas East Main Drainage Canal just prior to Arcade Slough. Grab samples were taken each half hour and composited over an eight-hour day. On May 16 the phenol concentration was 3 ppb and on May 17 no phenol was detected. The July 15 letter from McClellan stated that the phenol concentration of Magpie Creek at its junction with Natamas East Main Canal was consistantly below 2 ppb during early July.

The changes made at McClellan have reduced the phenolic material in Magpie Creek to a point where no further difficulties are expected with the Sacramento water supply. The biological oxidation

in the creek, downstream from the Base, reduces the phenolic concentration to negligible amounts in warm weather. Decreased biological oxidation that is to be expected during colder weather conditions will tend to be counterbalanced by dilution due to an increased water flow during this season.

RECOMMENDATIONS

Review of the data contained in this report and the supporting information presented makes possible formulation of definite conclusions. Implementation of the following recommendations pertaining to liquid waste control and treatment should protect the receiving stream.

1. Monitoring Program. This program will require daily sampling, measuring, and analyzing of the water in Magpie Creek and at the waste treatment plants discharging to this stream. Data thus obtained encourage efficient operation and provide an invaluable record.

2. Maintenance. Greater stress should be placed on equipment maintenance at these waste treatment plants. For example, the air flow measuring device and the pH equipment were defective at Plant 2.

3. Chemical Control. Control tests should be applied to the raw waste and appropriate adjustments should then be made in chemical dosage. Closer control of coagulants will give improved results and greater economy.

4. Oil Skimmers. Undesirable accumulation of oil in the equalizing tank at Plants 1 and 2 results from inadequate skimming facilities. Installation of a skimmer on a swinging elbow at each plant would permit daily skimming of this accumulated oil.

5. Expansion. Cooling water places a temporary overload on treatment Plant 1 during the summer. Study of this problem should be made a part of the long range waste control and treatment program to be investigated by a firm of Consulting Engineers.

6. Oily Sludges. Consideration should be given to more efficient in-

cineration of waste oil, oily sludges, and skimmings. Incineration would be facilitated by dewatering of these waste materials.

7. Terminal Lagoon. Irregularities in operation which will affect liquid waste discharge are inevitable at a plant the size of McClellan AFB. A terminal lagoon for storage and final treatment of the effluent from this Base will prevent slugs of pollutional wastes from entering the receiving stream.

8. Water Conservation. The desirability of a campaign to reduce the use of fresh water was indicated. This should be extended to water reuse as has been demonstrated in the engine cleaning department.

9. Engineering Services. The full-time services are needed of an engineer experienced in the fields of sewage and industrial waste treatment.

10. Supervision. Operators of the waste treatment plants would benefit from an operators manual. This manual should not only contain operating instructions but also should include sufficient information about the treatment process to create interest of the operator in his job. Closer supervision of the operators will pay dividends.

11. Consulting Engineers Study. These studies were confined to existing liquid wastes and waste treatment facilities. Methods for correcting deficiencies and of satisfying future requirements for control of both water and air pollution at McClellan Air Force Base should be investigated and reported on by a firm of consulting engineers.

ACKNOWLEDGEMENTS

This research was facilitated and expedited by the splendid cooperation of McClellan AFB personnel. The keen interest and excellent support of both Col. Marshall and Major Snodgrass contributed much to this project. The authors are grateful to Hayse H. Black for counsel in organization and conduct of this research and for critical review of this report.

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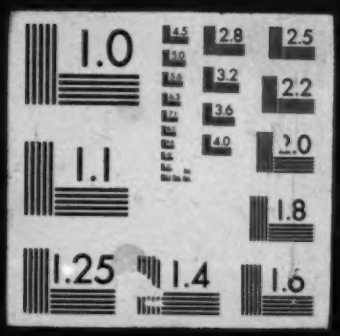

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Headquarters
McCLELLAN AIR FORCE BASE
California

In Reply
Refer To: SMBA

April 9, 1957

U. S. Public Health Service
Robert A. Taft Engineering Center
ATTN: Mr. Hayes Black
Cincinnati, Ohio

Dear Mr. Black:

The following request is in confirmation of conversations between Mr. Hayes Black of your organization and Lt Colonel J. B. Marshall, Installations Engineer, this Headquarters.

Request that you provide the full time services of one industrial waste engineer and one industrial waste chemist for a period of 60 days. Such services are to be provided at your earliest convenience after receipt of this request.

The services of these two people are to cover a study of the existing industrial waste system presently at McClellan Air Force Base, and to develop procedures toward the effective utilization of these plants to treat industrial wastes generated at this Base. Subject engineer and chemist will be under the personal direction of Mr. Hayes Black. Mr. Hayes Black is to spend sufficient time at this Base to insure effective utilization of these people.

A comprehensive report is desired on findings and actions. You are authorized to expend Air Force funds not to exceed $6,500.00 for this purpose. Transfer of funds is to be by Standard Form 1080.

Sincerely,

J. B. MARSHALL
Lt Colonel, USAF
Installations Engineer

MODIFICATION OF WASTE PLANT 3 TREATMENT PROCESS

Phase I: Action was initiated by Base Installations requesting the Materials Laboratory to furnish one chemist, on a loan basis, in an attempt to obtain a clear water effluent from the Waste Plant 3 treatment process. Mr. K. Lind, MIMB, was loaned to BA for this purpose.

A. Upon assumption of the project on 18 February 1957, the Plant 3 operation was found to consist of the following:

1. Water was received from Building 76, either into the raw water surface pit, or into the oil trap.
2. Water from the raw water surface pit could be routed to the oil trap as desired.
3. Water flowed through the oil trap, and by gravity into the pump pit.
4. On a float - demand basis, water was pumped into the clarifier.
5. Alum and lime slurry were added to the main water line between pump pit and clarifier.
6. Air was introduced into the clarifier through an air hose.
7. The clarifier operated as both a skimming and a sludging operation.
8. Water overflowed from the clarifier, and flowed by gravity to the surge tank.
9. Water was pumped from the surge tank into the pressure chamber. Air was introduced into the water at the pumps, and dissolved into the water by pressure in the pressure chamber.

10. Between the pressure chamber and the Flotator, alum and lime slurry were added into the main water line.
11. Water, containing the dissolved air, lime and alum, was discharged into the Flotator, where dissolution of the air, with its consequent effervescence yielded some floating floc. This floc was removed by skimming.
12. Water overflowed the Flotator and flowed by gravity into the 60,000 gallon holding tank.
13. Water could flow from the holding tank either to the sanitary sewage plant for biological oxidation or to the chlorinator for treatment.
14. Water which was diverted to the chlorinator was chlorinated in an alkaline medium, discharged into a holding tank, and thence discharged into Magpie Creek.

B. Discussion of the method of treatment is as follows:

1. The oil trap was undersized, and fluctuation in the flow of influent water was great. The trap accomplished very little toward removing oil, although the quantity of free oil received was small.
2. Treatment with lime, alum and air in the clarifier was intended to produce a floating floc of aluminum hydroxide. However, the effects of several factors prevented this:
   (a) Dosage rates were extremely high, and chemically uncontrolled.

(b) No consideration was given to the optimum pH of aluminum hydroxide formation. Consequently, the results ranged from an extremely high quantity of floc which overtaxed the ability of the clarifier to remove it, to re-solution of the formed floc when the pH became higher than pH 9.

(c) Addition of air from a hose rather than a diffuser served to agitate the formed floc, rather than to encourage its rise to the surface for skimming.

(d) The use of lime slurry as the alkaline precipitant for the aluminum hydroxide caused some weighting of the floc, which also diminished the tendency of the floc to rise to the surface for skimming.

3. The results of alum and lime dosage in the Flotator were similar to those in the clarifier.

(a) Lack of pH control gave variable results from heavy floc formation to none.

(b) Overdosage, with little delay time in the Flotator, caused heavy carry over of the floc when flocculation occurred.

4. The water effluent from the Flotator was a brown, translucent to opaque liquid containing emulsified oil, cresol, and considerable suspended solids. For this reason, the water could not be proportioned to the sanitary sewer plant for biological oxidation. Consequently, the water was either hauled away to an open pit, or routed to the chlorinator.

5. Chlorination of the water after the above process was accomplished in an alkaline medium. The reaction was predicated upon the successful chloro-oxidation of phenol, through dichloro-quinone, thence to maleic anhydride and carbon dioxide. However, because of chemical considerations, neither ortho- nor meta- cresol can form a dichloro-quinone. Hence, the chloro-oxidation of cresol does not proceed to a tasteless, odorless, non-toxic solution of maleic anhydride. Rather, it would tend to form chloro cresols with multiple chloro-substitutions on the methyl side chain. The benzene ring is not broken by the reaction, and the end product is more odorous, toxic compound than the original cresol.

C. Modifications were made in the foregoing process as follows:

1. Control of chemical dosage was established.

(a) Dosage of lime and alum was totally stopped.

(b) Water entering the clarifier was acidified with phosphoric acid to a pH of 2-3.

(c) Chlorination was totally stopped.

(d) Results of the above action yielded a clear effluent water at times. The action was to break soap emulsions by acidic desaponification, which allowed the removal of oils and soaps by clarifier and flotator action. However, the treatment was not consistently successful, but dependent upon the degree of emulsification, and types of emulsifying agents in the influent water.

2. Clay adsorption was begun.

   (a) In addition to the dosage with phosphoric acid, clay and alum were used as dosages into the waste water just prior to entry into the clarifier. The clay acted as an oil adsorbant, and the alum acted both as a floc forming agent, and as a discharging agent to speed coagulation of colloidal clay particles.

   (b) This method of treatment resulted in the formation of a heavy (sinking) floc, and produced a consistently clean effluent containing no visible oil, only a slight turbidity due to suspended solids, and containing 100-600 ppm of dissolved cresol, depending on the cresylic content of the water received for treatment.

Phase II: Recirculation of treated water to the Engine Repair rinse tanks for re-use.

A. The use of phosphoric acid, clay and alum dosages yielded a water effluent requiring only a pH adjustment to neutrality in order to produce water suitable for re-use in the Engine Repair cleaning cycle.

   1. A pit 65 feet by 20 feet, 20 inches deep was filled with 3/8" x 1/8" crushed limestone. Treated water from the 60,000 gallon holding tank was passed through this limestone bed, yielding a neutral (pH7) water, which was then successfully returned and re-used.

B. Re-use of the treated water yielded a closed system in which only sludge, skimmings and oil required disposal by haulage, and in which no waste water was discharged into Magpie Creek.

Phase III: Upon the establishment of a recirculating water system, operation of Waste Plant 3 became a function of the Maintenance Directorate. This transfer was officially accomplished on or about 1 April 1957, and plant operation became a function of the Materials Laboratory Section (MIMB), Materials and Process Branch (MIM).

Phase IV: Addition of other cresylic bearing wastes to Waste Plant 3.

A. Upon assumption of operational responsibilities by MIMB, the total water influent to Plant 3 was approximately 14,000 gallons per day. With the elimination of Plant 3 as a source of cresols to Magpie Creek, surveys conducted by U. S. Department of Public Health and Base Installations detected other sources yielding cresylic contamination of the Creek. As a result, two further sources of water and contaminants were added to the Plant 3 influent:

1. An estimated 9,000 gallons per day were added from the engine pre-cleaning operation. This water contained a great deal of free oil, plus some emulsified oil and dissolved cresol.
2. A drum-washing operation was moved to Plant 3, so that drums which had contained cresylic materials could be washed into the waste plant system, rather than into Magpie Creek. This operation added little extra water, since treated plant water was used for washing, but considerable quantities of oily material and cresols were added to the Plant 3 influent.

B. Receipt of the new contaminants upset the previously established treatment process, primarily as a result of large increases in the quantity of oil received. The oil selectively adsorbed the clay, and emulsion treatment in the aqueous phase was incomplete as a consequence.

1. Higher dosages of clay were employed in an attempt to offset the effect noted. This remedy was only effective in part, since the high clay dosages caused carry over of clay through both the clarifier and the Flotator, and emulsion destruction was only partial.
2. "Separan," an acrylic polymer used for rapid clay flocculation, was tested to prevent clay carry over. This treatment was successful in removing the excess clay, but in the recirculation of the treated water, "Separan" concentration built up in the water to the point where clay was coagulated and precipitated immediately upon entering the waste water. This gave the clay no time to accomplish oil adsorption, resulting in a consequent failure of the treatment process. Since the "Separan" was an organic polymer and hence difficult to analyze on a routine basis this method was temporarily abandoned.
3. A more efficient oil trap was requested. Pending completion of the trap, water received from Engine Repair was first routed to the surface pit and then pumped to the clarifier. This permitted separation and retention of free oil in the surface pit. As a result, treatment of water by the alum-clay-phosphoric acid process again became possible and successful.

C. Further cresylic contamination was found in the water discharged from the pre-soak tanks in the Engine Repair cleaning cycle. Consequently, an additional estimated 9,000 gallons per day of waste water was added to the Engine Repair wastes already entering Plant 3.

1. The increased load imposed upon the plant operation required an increased dosage of clay and alum. This sludge accumulated so rapidly that very frequent sludging of the clarifier and surge tank was required to prevent sludge carry over throughout the system.

   (a) The use of less clay, and the use of "Separan" was again tried. A control test based upon rate of clay coagulation was made in treated water to estimate the amount of "Separan" present in the recirculated water. "Separan" effects were controllable in this manner, but treatment was still relatively ineffective because of a slow settling rate compared to the volume of waste water received.

   (b) A further attempt was made to use an aluminum hydroxide floc alone to attain water treatment. Use of limestone as a neutralizing method was stopped. This method had been decreasingly effective due to slow flow rate, surface passivation of the limestone, adsorption of oily materials during periods of ineffective water treatment, etc. Automatic pH control at the inflow of the Flotator, using soda ash as the alkaline compound was begun. This treatment was found to be highly effective in removing residual alum from the waste water. Hence, phosphoric acid and clay dosages were

stopped, and a solution of 0.5 lb./gallon of alum was added to the waste water prior to clarification. The water received, because of pH control during treatment prior to water reusage, had a pH of 7.0 to 7.5. This allowed coagulation of the added alum, and produced a light (floating) floc, due partly to occluded oily material. Much of this formed floc was removed by skimming and sludging at the clarifier. The water effluent from the clarifier was clear, with some residual suspended floc. This residual aluminum hydroxide floc was almost completely removed at the Flotator, by pH adjustment to 7.0 immediately prior to entry of the water into the Flotator. Final treatment of the water was was accomplished by passage through two sand filters. The treated water was transparent, showing only a faint turbidity, yellowish in color, containing about 400 ppm cresol and 10-20 ppm of oils. This water was suitable for reuse, by Engine Repair and for biological oxidation of cresylics in the Sanitary Sewage Plant.

Phase IV: Bleed-off to the Sanitary Sewage Plant.

A. Production of the quality water noted above made possible the inception of a daily bleed-off from Plant 3 into the Sanitary Sewage Plant. The need for such a system arose from several sources:

1. The tendency of certain contaminants to build up in a completely recirculated system.

2. A desire to use fresh water in the final Engine Repair rinse tank. (This step assures clean, scale-free parts leaving the cleaning cycle.)
3. A need for a relief system to relieve Plant 3 of water should various factors result in volume increase within the plant, i.e. rainwater, tap water used in Engine Repair, water from various steam traps, etc.

B. The bleed-off was originally intended to be 10,000 gallons per day. However, a lower initial biological oxidation efficiency than predicted, and the possible presence of ortho-dichlorobenzene in the treated water, caused this to be cut to 3,000 gallons per day at first, and then increased to 5,000 gallons per day. This quantity should approximately equal the amount of water used in the final Engine cleaning rinse tank. However, heavy winter rains may necessitate a greater bleed-off than this amount.

Phase V: The new gravity oil separator (oil trap) was completed and began operation on June 24, 1957.

Future Requirements:

A. A second pH controller (on hand) will probably be used to more closely control the alum dosage prior to clarification. Past experience indicates that optimum treatment is obtained when water is received at a pH of 7.0 to 8.0, and is dosed with alum to a resultant pH of 3.0 - 4.0.

B. Pump tests have shown that the volume of water influent to Plant 3 is actually from 50,000 to 55,000 gallons per day, rather than the estimated total of 31,000 to 32,000 from all sources. This is the maximum capacity for the plant on a two shift operation. A short period of three shift operation was recently necessary to keep pace with shop demand for treated water. Present operation is on a two shift basis.

C. If biological oxidation efficiency of the Sanitary Sewage Plant on the cresol contaminated bleed-off does not increase, then operation of the Podbielniak extractors can be used to assist in producing a satisfactory effluent water. This would be accomplished by removal of about 95-97% of the cresol by extraction with the Podbielniaks, and a 90-95% removal of the remaining cresol by biological oxidation. This treatment would remove 99.5% to 99.7% of the cresol originally contained in the bleed-off water; 5,000 gallons per shift could be removed from the Plant 3 system in this manner. Final concentration of cresols in Magpie Creek water would be 0.008 ppm from this source if 10,000 gallons per day of water containing 500 ppm of cresol were treated in this manner and released into the creek, where the flow rate is estimated to be 3,000,000 gallons per day.